

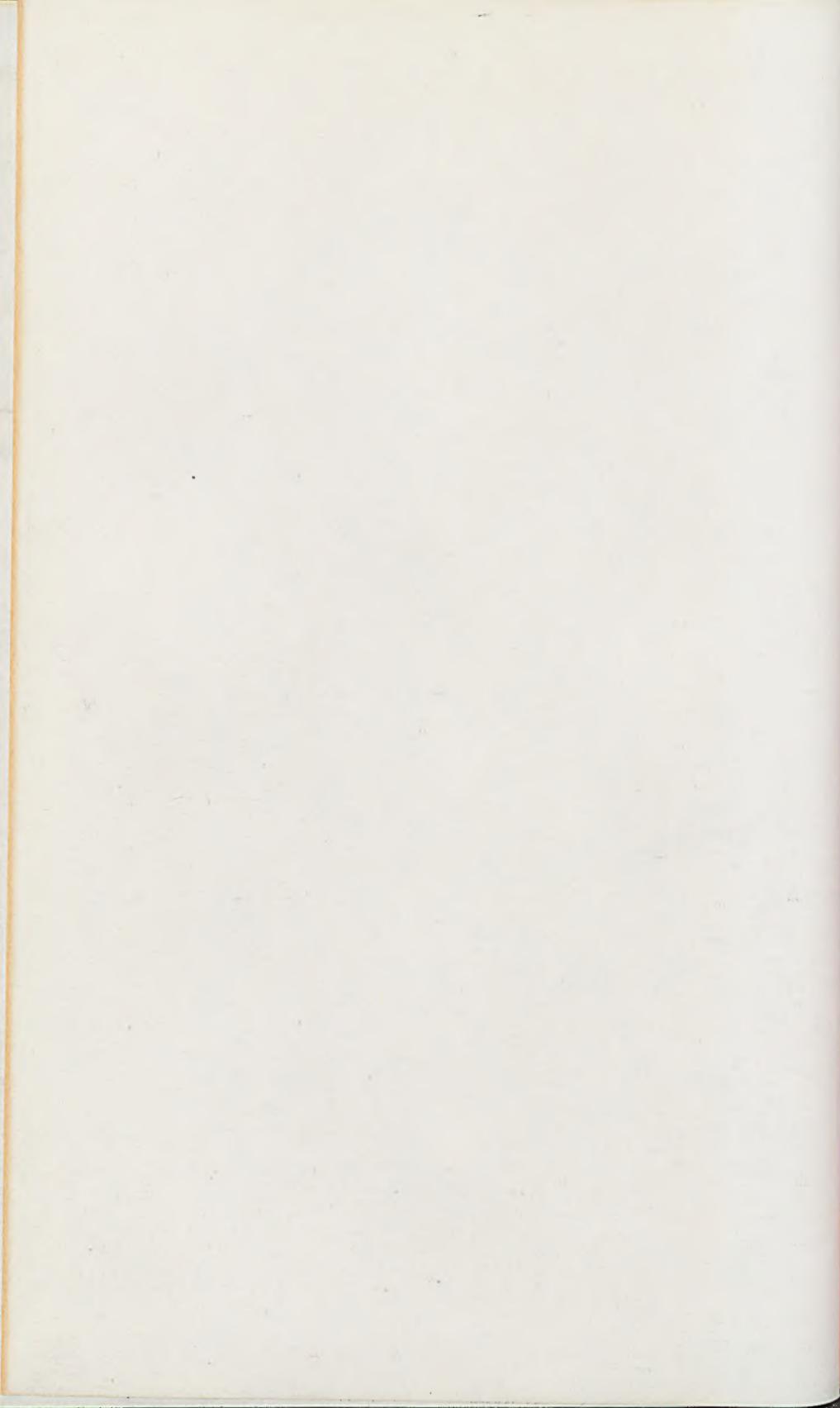
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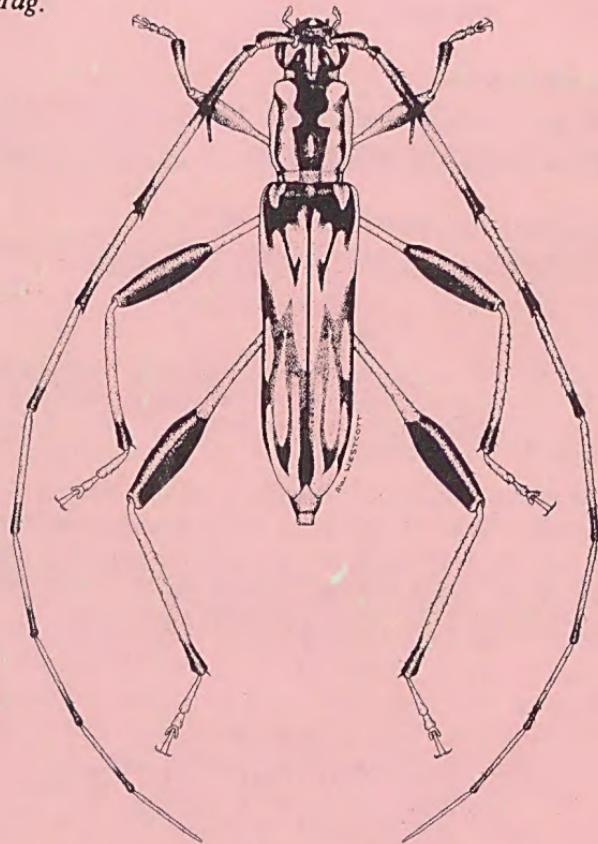




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## COVER

Illustrated by Alan E. Westcott.

Depicts the citrus longicorn, *Skeletodes tetrops* Newman, the larvae of which are commonly found in decaying citrus wood in eastern New South Wales. Eggs are laid in dead bark, usually after damage by other longicorn species, and the larvae make shallow tunnels packed with flour-like frass. The species is not considered to be economically significant.

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# Australian Entomological Magazine

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## CROP EVERSION IN CHAOBORID LARVAE (DIPTERA)

By D. H. Colless

CSIRO, Division of Entomology, P.O. Box 1700, Canberra City, 2601

### Abstract

On the available evidence it seems likely that the larva of *Chaoborus* normally, but perhaps optionally, voids the remains of its prey by evertting the crop. For other chaoborid genera the evidence is less convincing, and crop eversion, as seen in specimens, may be only an artefact of preservation.

With one known exception, the larvae of Chaoboridae are aquatic predators (the exception is the filter-feeding *Australomochlynx nitidus* Freeman; Colless 1977). However, the way that they consume their prey seems unique amongst insects. Mature chaoborid larvae prey mainly on small crustaceans (copepods, ostracods, and cladocerans); but larger creatures, such as mosquito larvae or other chaoborids, may sometimes be taken (Edwards 1932, Wesenberg-Lund 1943, Deonier 1943, James 1957, O'Connor 1959, Swift and Fedorenko 1975). The prey is swallowed whole into a long, distensible, muscular crop that terminates posteriorly at a sphincter that may bear spines or plates, forming a sieve. Strong contractions of the crop squeeze the prey and expressed body fluids are filtered at the sphincter while being pumped to the midgut. According to Montshadsky (1945) digestion, too, occurs in the crop, by enzymes pumped back from the midgut.

So much seems well established, as is, too, the fact that larvae are only occasionally seen with prey in the crop. It follows that the pellet of compressed remains is voided from time to time, and that it must be voided through the

mouth, since the pellet could not pass the sphincter; but the question remains precisely how is it ejected?

The question would be pretty trivial were it not for a striking and unusual feature of chaoborid larvae: preserved specimens often have the crop completely prolapsed through the mouth opening. Edwards (1932) describes this as a feature of all genera of Chaoboridae with the possible exception of *Corethrella*; and I can now report having observed it in a specimen of an undescribed Australian species in that genus. The fact that eversion of the crop tends to be uniformly present or absent in a given batch of specimens shows that the phenomenon, as seen, is an artefact of preservation. No doubt it is caused by a sudden increase in blood pressure through diffusion of fixative or muscular contraction; Deonier (1943) reports eversion following light pressure with a needle. Nonetheless, if the crop is so easily everted, it might perhaps occur naturally as a means of ejecting the remains of the prey. And that would add yet another distinctive feature to a most unusual kind of feeding behaviour.

Two authors have asserted that in *Chaoborus* eversion is in fact a normal feature of behaviour (Herms 1937, for *C. astictopus* Dyar and Shannon; and Montshadsky 1945, for *C. crystallinus* de Geer). Herms was retailing observations by a trusted field officer, R. W. Burgess, who had abundant opportunity to study live material; and Montshadsky leaves no doubt that he actually observed prolapse of the crop. In addition James (1957) states that in *Mochlonyx velutinus* (Ruthe) remains of the prey are 'ejected by the eversible crop'; but it is not clear whether he actually observed eversion to occur.

On the other hand Deonier (1943), also studying *C. astictopus*, found that the crop was emptied simply by reverse peristalsis. He saw eversion 'only in injured specimens'. Likewise O'Connor (1959) observed only 'regurgitation' in *Mochlonyx cinctipes* (Coq.). I can add to these my own observation of a single case of reverse peristalsis (and none of eversion) in larvae of an Australian species of *Chaoborus* ("Ingham species", undescribed). It is extremely difficult to catch a larva at the precise moment of clearing its crop; but if eversion was regularly practised by larvae in the batch that I watched, then retraction must have been very rapid.

The simplest interpretation of these conflicting reports would be that *both* forms of behaviour occur. However, most folk would, I think, remain suspicious of the eversion story without additional supporting evidence. As it happens, this can be easily found in the case of *Chaoborus*. Measurements of two Australian species and on Figure 3a in Herms (1937) show that the crop constitutes about one quarter of the total length of the gut. If, then, a larva regularly and suddenly to protrude through its mouth such a substantial part of its viscera, we might expect to find correlated adaptations that act to minimise traumatic side effects. And such a feature is plainly evident in the posterior segment of the oesophagus. This segment is about as long as the crop but much narrower, with a fine lumen and walls of compact muscle that include conspicuous longitudinal members. It should therefore serve admirably as a

elastic device to absorb both shock and displacement if the crop were suddenly everted. Indeed, it is hard to imagine what other function it could serve.

I therefore find it quite credible that *Chaoborus* larvae have eversion of the crop as a normal, but optional feature of behaviour. The option might be exercised only when the fully compressed prey still distends the crop past some limiting volume, through capture of an unusually large creature or several smaller ones in quick succession. Such distension could be expected to increase the larva's blood pressure so as to assist, if not by itself to mediate, eversion of the crop.

On the other hand, there is little to suggest that such behaviour occurs normally in other chaoborid genera. My own observation of *Australomochlonyx*, *Promochlonyx*, *Mochlonyx* (*M. culiformis* de Geer), *Eucorethra* and *Corethrella* (2 unnamed species) show that all have the crop connected to the midgut by a short and unremarkable segment of oesophagus. It is therefore hard to believe that in these genera frequent and total eversion of the crop would not be damaging to the rest of the gut. It might, of course, occur occasionally as an unfortunate addicent, of a kind that the highly specialised *Chaoborus* has turned to its benefit.

A final question: how is the prolapsed crop retracted? According to Montshadsky (1945) it is "swallowed with the help of the mouthparts and the antennae". In fact, it is a fair conjecture that the protruding crop is perceived as prey and eaten in the normal fashion. So it may be no coincidence that, as also noted by Montshadsky, *Chaoborus* does little physical damage to its prey while swallowing it!

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## OBSERVATIONS ON THE BIOLOGY OF *SEXTIUS VIRESSENS* (FAIRMAIRE) (HOMOPTERA, MEMBRACIDAE) ON *ACACIA* IN VICTORIA

By L. Cookson and T. R. New

Department of Zoology, La Trobe University, Bundoora, Victoria 3083.

### Abstract

*Sextius virescens* is univoltine near Melbourne, Victoria, with eggs being the major overwintering stage. Adults may live for more than 30 weeks. Host range, reproductive and defensive behaviour are briefly described, and notes given on insect predators and parasites. Records of Mymaridae, Trichogrammatidae and Pipunculidae are the first from an Australian membracid.

### Introduction

The green membracid *Sextius virescens* (Fairmaire) is one of the more common insects on acacias in south-eastern Australia (Froggatt, 1902), but little information has been published on its biology and life history. Kitching (1974) described and differentiated the early stages of *S. virescens*, and Kitching and Filshie (1974) used *S. virescens* for their study of the anal apparatus of membracid nymphs. Virtually no biological information is available for other Australian Membracidae, although a number of host records were summarised by Evans (1966).

A one year study of *S. virescens* near Melbourne, Victoria, augmented by observations over several years, has enabled some clarification of its life history to be made, and has yielded preliminary data on its insect parasites and predators in this area.

### Methods

Direct total counts of adults and nymphs were made, and the incidence of eggs noted at weekly or fortnightly intervals from February 1978 to February 1979 on 93 *Acacia* trees (all < 3 years old and mostly ca. 1 m in height) representing 18 species (Appendix 1) on the La Trobe University campus. Additional larger trees in the same area were used as the source of laboratory material and membracids were maintained in the laboratory on potted seedlings, mainly of *A. decurrens*. Terminal branch lengths were cut and brought to the laboratory for examination for eggs, and possible predators were collected by direct searching (small trees) or beating (larger trees).

### Life History

The months in which eggs, nymphs and adults were found are shown in Fig. 1, which clearly shows that *S. virescens* is univoltine. Adults first appeared in December, and were abundant from January until March. Thereafter, there was a progressive decline in adult numbers, although a few persisted through the winter until late September and early October. Oviposition commenced about one month after appearance of the first adults, and healthy unhatched eggs were present until the following November, although many hatched in October. During most of November and December only nymphs were present, and a few late instar nymphs occurred until April (on three of 93 trees). Most became adult within about two months of eclosion.

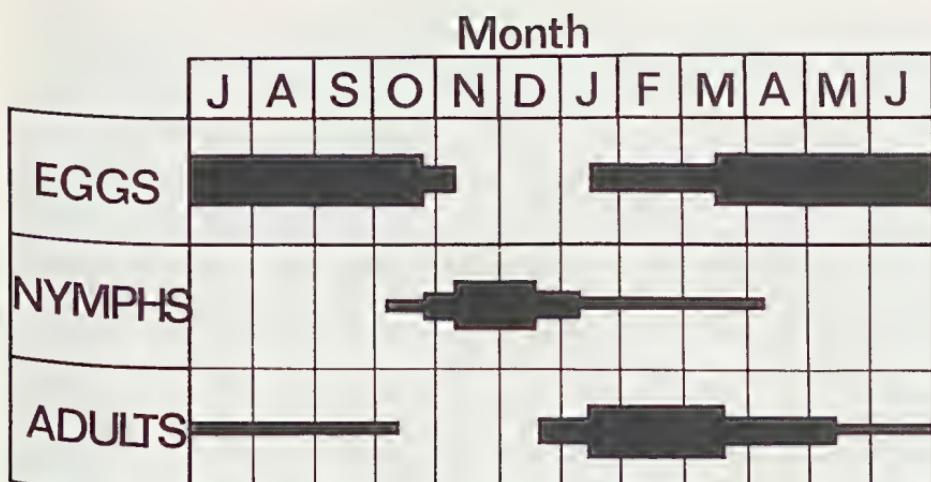


Fig. 1. Summary of periods of occurrence of eggs, nymphs and adults of *S. virescens* on *Acacia* near Melbourne, 1977-78 (width of bar proportional to abundance, months denoted by initial letter from July to June).

The egg is thus the major overwintering stage, and eggs remain unhatched for eight to nine months. In 1978 most hatched during the latter half of October. In a sample taken on October 19 most eggs were unhatched but showed the eyespots characteristic of advanced embryos and on October 31 large numbers of first and second instar nymphs and few unhatched eggs were found. This relatively short hatching period is suggestive of an egg diapause. Early instar nymphs were scarce after late November.

Marking, using coloured nail polish, and subsequent release of field-collected adults showed that longevity could be as long as 33 weeks or more. Monitoring of marked adults also showed that an individual may occur on more than one host species, and that adults from the same original host may disperse to several different hosts.

Many adults undergo a progressive colour change with age, changing from bright green to dull yellow. Yellowing starts in the region of the suprhumeral horns, and progresses posteriorly. It does not occur in all individuals, however, and thus differs from the more general colour change associated with maturity in some other membracids (Wood, 1975).

#### Mating

*S. virescens* does not show any elaborate female display such as, for example, that recorded in *Umbonia crassicornis* Amyot and Serville by Wood (1974). Before mating, *S. virescens* males initially either stopped beside, or walked behind, a female. The male then sits on the female, usually directly above her, with his head at or behind the level of her suprhumeral horns for one or two days. Up to three males were seen sitting on one female, even if unattended females were near. Copulation occurs with the partners facing in opposite directions which is the usual membracid position.

### Oviposition

Eggs are laid in a single row in slits cut through the bark of young *Acacia* branches (Froggatt, 1902). The eggs are deposited between the bark and underlying cortex.

Initially the ovipositor is lowered at right angles to the branch and the substrate palpated repeatedly until a site for commencement of cutting has been selected. The tip of the ovipositor is then forced into the bark, and the female moves progressively backwards, opening a narrow vertical slit. After a short period of rest, during which the ovipositor is sheathed, the abdomen is arched forwards and the ovipositor used to cut deeper and push laterally into part of the slit, broadening the cut from about 0.1 mm to about 0.3 mm wide. After cutting in this manner for a single arching of the abdomen, an egg is inserted into the slit. The ovipositor is withdrawn, sheathed, and the process repeated after several minutes until a row of eggs has been laid. One female observed took an hour to lay eight eggs.

Slit lengths and numbers of eggs per slit found in field-collected samples from three *Acacia* species are shown in Table 1. Slits in *A. decurrens* were usually slightly longer than on the other two tree species, and the differences may reflect structural features of the different hosts. In particular, *A. verticillata* has whorls of phyllodes separated by only short lengths of stem.

TABLE 1  
Oviposition slit lengths of *Sextius virescens*, and numbers of eggs contained in slits, on three *Acacia* species (bulked samples, 1978)

Host	No. of slits examined	Slit length (mm, mean $\pm$ s.d., range)	Egg number (mean $\pm$ s.d., range)
<i>A. decurrens</i>	75	9.21 $\pm$ 2.0 (2.5-16.5)	13.9 $\pm$ 4.3 (0-25)
<i>A. verticillata</i>	25	7.18 $\pm$ 1.5 (4.5-10.0)	12.2 $\pm$ 3.5 (6-19)
<i>A. acinacea</i>	25	7.40 $\pm$ 1.6 (3.0-11.0)	12.0 $\pm$ 3.2 (5-16)

In some instances, slits were not completely filled with eggs, and several empty slits were found. These may reflect females being distracted during oviposition. More rarely the females make individual slits for each of several eggs.

Dissection of females throughout their period of occurrence gave an overall average ( $n = 160$ ) of  $16.2 \pm 6.3$  fully developed (chorionated) eggs, a figure slightly higher than the average number contained in a single slit. The greatest number of developed ovarian eggs was 35, strongly suggesting that a single female may sometimes make more than one slit at oviposition. Close synchronisation of eclosion of nymphs from adjacent slits may also suggest this. Newly adult females had a mean ovarian count of only 0.4 eggs, and females taken from precopulatory pairs contained a mean of 5.1 eggs ( $N = 10$  in each case).

Females appear to be considerably more abundant than males. Overall sex ratio for samples examined was 21% males ( $N = 978$ ), with several small populations containing only females. No samples from any individual tree were

found with more males than females (maximum 46.4% males,  $N = 181$ ). In general, the proportion of males was higher in close aggregations than in more dispersed 'groups', possibly reflecting a greater tendency for males to disperse.

### Natural enemies

There appear to be no records of natural enemies of Australian Membracidae and, in general, the family has few parasites and predators recorded from elsewhere in the world (Funkhouser, 1950). Wood (1975) discussed predation by lizards on several new world Membracidae, and Hinton (1976) noted the possible defensive function of aggregation. Hinton commented that 'the mere presence of the adult above a batch of eggs may ensure their greater survival simply by blocking the approach of casual predators and parasites'.

All stages of *S. virescens* were examined for the incidence of insect parasites and several possible arthropod predators were tested against them under artificial conditions to determine whether they could utilise them as prey. No vertebrate predators of *Sextius* were observed.

### Parasites

One (possibly two) species of Mymaridae and one of Trichogrammatidae were reared from *S. virescens* eggs, and four adult *Sextius* were found parasitised by a pipunculid fly. No parasites were found in *Sextius* nymphs.

The Mymaridae are two of three known species (all undescribed) which are apparently referable to a new genus of Anagrini, near *Stethynium* Enoch, (New, unpublished). The trichogrammatid is represented only by four somewhat damaged specimens. The pipunculid was determined as *Pipunculus* sp. by Dr D.H. Colless (CSIRO). Specimens of all will ultimately be deposited in the Australian National Insect Collection, Canberra. Comments on the individual species follow.

One species of mymarid was common. Fifty egg slits (total 677 eggs) gave an overall level of parasitism of 39.4%. Thirty eight of these slits contained some parasitised eggs, but only in seven were all eggs parasitised. The wasp probably oviposits in *S. virescens* eggs before winter, and its pupae were found in membracid eggs in late winter. Parasites emerged mainly during September and were found walking on infested branches in the field at that time. They appeared to attack mainly eggs that were at least partially exposed. Eggs enclosed completely by the slit, or by encrusted dried sap or debris were only rarely parasitised.

A single specimen of a second mymarid species was found in a box containing *S. virescens* eggs in the laboratory in August 1978. The association has not been confirmed, but there did not appear to be any other possible host in the container.

The trichogrammatid is known from one clear incidence. An egg slit on *A. decurrens* examined on October 19 contained an adult wasp in the act of oviposition. Wasps subsequently emerged from several other eggs in the same slit. In contrast to many other egg parasites, which normally attack before

appreciable development of the host embryo has occurred, this species can successfully attack well-developed eggs.

The fully developed pipunculid larva broke out of the adult *Sextius* at the junction of the thorax and abdomen. The larvae pupated on the cage floor about a day later, and the two adults reared emerged after about three weeks. The parasitised adults were field-collected, but it is likely that the fly attacks later nymphs, a habit common in Pipunculidae reared from other hosts.

It thus appears that the greatest parasite mortality is inflicted during the egg stage, predominantly by one species of mymarid.

#### Predators

Adults and nymphs of the mantis *Orthodera ministralis* (F) were observed feeding on adult *Sextius* in the field. In the laboratory, adult *O. ministralis* could eat up to seven adults a day. First instar *Orthodera* were unable to handle *S. virescens* larger than third instar, but readily fed on young nymphs. Adult earwigs (*Forficula auricularia* L), and last instar larvae of *Chrysopa edwardsi* Banks also fed readily on nymphs of *S. virescens* under confined conditions, but could not capture adults. Several spiders were seen feeding on adult membracids on *Acacia* trees, and a species of Thomisidae ate up to two adults a day in the laboratory.

#### Discussion

*S. virescens* was by far the most abundant membracid found in *Acacia* during this study. It is univoltine, with eggs comprising the major overwintering stage, and the level of egg parasitism is high. Balduf (1928) showed (for parasitism of *Ceresa bubalus* eggs by *Polynema striaticorne* Girault) that avoidance of synchronous parasitism of all eggs could be important in ensuring the continuity of the parasite, as growth or shifting of bark could influence egg availability. This may possibly occur in *S. virescens*, as the long period of egg incubation and rapid growth of young *Acacia* branches could combine to affect egg position. Maternal brooding and such devices as a 'froth cove' (Wood and Patton, 1971: *Enchenopa binotata* Say) are not available for protection of *S. virescens* eggs, and egg insertion into plant tissue is thus the major 'protective mechanism' available. It is not known whether the level of parasitism found reflects only one generation or several compounded generations of the parasite over the period: laboratory emergences strongly suggest only a single parasite generation, as most parasites emerged over a very short period.

In contrast to eggs, the nymphs and adults have only low levels of parasitism. The incidence of *Pipunculus* (although low) is of considerable interest in documenting an unusual host record, as these flies are more usually associated with other groups of Homoptera. Most of the few host records of Australian Pipunculidae are of species from leaf hoppers (Hardy, 1964), and Coyle (1966) indicated that each pipunculid genus is usually limited to one host family, e.g. *Pipunculus* to Cicadellidae.

No evidence was found of egg predation, but several predators of late stages are recorded. Both mantids and spiders were listed amongst predators

of membracids by Funkhouser (1917), and these were the only field records of predators during our work. *Chrysopa edwardsi* is the most abundant chrysopid on *Acacia* in southern Victoria and, as larvae readily ate membracids when confined, this may reflect a regular feeding association.

Kitching and Filshie (1974) suggested that the anal whip of *S. virescens* nymphs might act as a defense against natural enemies, believing that the whip (which is extruded and 'whipped' when nymphs are physically disturbed) might make it difficult for predators to manoeuvre to grasp the prey. Against the above-mentioned predators, however, the whip was used only after the nymph had already been gripped or picked up, and its action did not then cause the predators to release their prey. We suggest that the anal whip could also be a useful adaptation to a sedentary existence. Nymphs of both *S. virescens* and *Cebes transiens* (Walker) were seen on many occasions with small drops of honeydew dispersed on the substrate in a semicircle around the abdomen at a distance approximating the length of the extended anal whip. It is well known that body contamination with honeydew is deleterious to some Homoptera (Way, 1963), and *S. virescens* nymphs with honeydew on their bodies appeared to be agitated and often to have their movement substantially impaired. Hinton (1976) showed that gregarious Membracidae (which are usually ant-attended) often have shorter anal tubes than solitary species. However, some more solitary species (such as *C. transiens*) and individuals (many *Sextius*) are often only irregularly ant-attended, and removal of honeydew may become relatively important.

Other membracids found on *Acacia* during this work were *Ceraon vitta* (Walker) (on *A. decurrens*, *A. pycnantha*, *A. retinodes*), *Cebes transiens* (Walker) (*A. decurrens*) and *Acanthucus trispinifer* (Fairmaire) (*A. decurrens*). Host records for the latter two species have apparently not been previously published, but *C. vitta* was recorded from *A. decurrens* by Goding (1903), who also recorded *Pogonella bispinus* (Stal) from this host. Evans (1966) commented that several species are known to live on acacias, which he noted as being hosts of very few Australian cicadellids. However, little is known of the hostplant relations of most Australian Membracidae and speculation that they may 'specialise' on acacias is premature. Clearly *S. virescens* utilises host species from several sections of the genus *Acacia*, but is known only from *Acacia*, and there is no evidence of transfer between *Acacia* and herbaceous plants as Balduf (1928) found for *Ceresa bubalus* (F). Although there were marked differences in numbers of individuals on different *Acacia* species, there was also considerable variation in numbers between plants of the same species. It is, therefore, difficult to suggest whether particular host species are 'preferred' by *S. virescens* as differences in numbers may merely reflect differences in individual tree condition. Tendency to form aggregations introduces a further bias into such estimations based on numbers alone. Although *S. virescens* is noted as being 'subsocial' by Hinton (1976) [apparently extrapolating from a comment by Kitching (1974) that 'all stages may be found together on the same plant'], this behaviour is much less pronounced than in some other membracids (Hinton, 1976), and 'secondary' aggregations are formed by adults becoming grouped.

### Acknowledgements

This paper includes data from a thesis submitted for the B.Sc. Honours degree at La Trobe University by L.C. Additional data were obtained with the technical assistance of Mrs J. TenBerge and Miss P. Fischer. We also thank Dr D. H. Colless for his identification of the pipunculid parasite.

### Appendix 1

List of *Acacia* species on which *S. virescens* were found, 1978.

<i>A. acinacea</i> Lindl.	<i>A. mucronata</i> Willd.
<i>A. armata</i> R.Br.,	<i>A. obliquinervia</i> M. Tindale.
<i>A. botrycephala</i> (Vent.) Desf.	<i>A. podalyriifolia</i> A. Cunn.
<i>A. buxifolia</i> A. Cunn.	<i>A. pravissima</i> F. Muell.
<i>A. decurrens</i> (J. Wendl.) Willd.	<i>A. pycnantha</i> Benth.
<i>A. floribunda</i> (Vent.) Willd.	<i>A. retinodes</i> Schlecht.
<i>A. hakeoides</i> A. Cunn.	<i>A. stricta</i> (Andr.) Willd.
<i>A. mearnsii</i> Willd.	<i>A. suaveolens</i> (Sm.) Willd.
<i>A. melanoxylon</i> R.Br.	<i>A. verticillata</i> (L'Herit.) Willd.

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## SYSTEMATIC NOTES ON *GRAPHIUM FELIXI* (JOICEY AND NOAKES) (LEPIDOPTERA: PAPILIONIDAE)

By D. L. Hancock

Department of Entomology, University of Queensland, St. Lucia, 4067†

### Abstract

The systematic position of *Graphium felixi* (Joicey & Noakes) is examined. Currently regarded as a form of *G. thule* (Wallace), it is here placed as a subspecies of *G. deucalion* (Boisduval) (stat. nov.).

### Introduction

In May and June, 1914, A. C. and F. Pratt collected on the island of Biak (Irian Jaya) a small series of a butterfly subsequently described by Joicey and Noakes (1915) as *Papilio felixi*. Although Joicey and Noakes stated that their new species was close to, but distinct from, *P. thule* Wallace, the taxon is currently treated as *Graphium thule* form *felixi*. D'Abrera (1971) noted that *felixi* is restricted to Biak, whereas the other described forms of *thule*, f. *princeps* Weymer, f. *leuthe* Grose-Smith and f. *thule*, occur throughout the species' range. Furthermore, the behaviour of *felixi* differs from that of *thule* (R. Straatman, pers. comm.). Examination of the male genitalia also suggests that these two taxa are not conspecific.

### Systematic relationships

The male genitalia of eight of the twelve species in the *Graphium macareus* group [*lencelades* (Boisduval), *xenocles* (Doubleday), *delessertii* (Guérin-Méneville), *ramaceus* (Westwood), *macareus* (Godart), *megarus* (Westwood), *deucalion* (Boisduval) and *thule*] were dissected and compared with those of *felixi* (Fig. 1). Of these eight species only two, *deucalion* (Fig. 2) and *thule* (Fig. 3), have the dorsal spiny process of the valva deeply emarginate and "finger-like". The valva of *thule* differs from that of *deucalion* and *felixi* in being distally emarginate and having the row of spines on this edge much reduced. In pattern also *felixi* resembles *deucalion*, being distinct from *thule*.



Figs 1-3. Valva and clasper of: (1) *Graphium deucalion felixi*; (2) *G. deucalion deucalion*; (3) *G. thule*.

† Present address: Plant Protection Res. Inst., P.O. Box 8100, Causeway, Salisbury, Rhodesia.

*Graphium felixi* should therefore be removed from the *thule* complex and the question now arises as to whether it should be given species status or associated with *deucalion*, which is comprised of two subspecies, typical *deucalion* in Sulawesi and subspecies *leucadion* in the Northern Moluccas. Evidence of a faunal affinity between Biak, the Moluccas and Sulawesi is seen in other organisms: the owl *Otus manadensis* Quoy & Gaimard occurs as separate subspecies in Sulawesi and the Lesser Sundas, in the Moluccas and on Biak, yet is absent from the mainland of New Guinea and other associated islands such as Waigeu and Mefor (Hekstra, 1973). Similarities in dispersal patterns between butterflies and birds have been demonstrated by Holloway and Jardine (1968) and *felixi* is thus associated with *deucalion*.

The classification of *deucalion* and *thule* should therefore be amended as follows:—

*Graphium deucalion*

- G. d. deucalion* (Boisduval) [Sulawesi]
- G. d. leucadion* (Staudinger) [N. Moluccas]
- G. d. felixi* (Joycey and Noakes) stat. nov. [Biak]

*Graphium thule*

- G. thule* f. *thule* (Wallace) [New Guinea]
- G. thule* f. *princeps* (Weymer) [New Guinea]
- G. thule* f. *leuthe* (Grose-Smith) [New Guinea]

*Graphium stratocles* (C. & R. Felder), from the Philippines, is probably most closely allied to these two species, all three having the pale scales of the fore wing upperside narrow and hair-like.

**Acknowledgements**

I wish to thank Dr I. F. B. Common (ANIC, Canberra), Mr E. C. Dahms (Queensland Museum) and Mr T. L. Fenner (DPI, Port Moresby) for the loan of specimens used in this study, Mr Ray Straatman for his comments on the behaviour of *felixi* and Dr T. E. Woodward for his supervision of the project of which this paper is a part. I also wish to thank Mr R. I. Vane-Wright and Mrs R. Arora of the British Museum (Natural History) for providing a detailed figure of the male genitalia of *felixi*.

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**THECLINESTHES MISKINI (T. P. LUCAS) (LEPIDOPTERA: LYCAENIDAE)  
FROM NORTH-WESTERN IRIAN JAYA, INDONESIA**

By A. Sibatani  
30 Owen Street, Lindfield, N.S.W. 2070

**Abstract**

*Theclinesthes miskini* (T. P. Lucas) is recorded for the first time from the Vogelkop area of Irian Jaya, Indonesia. Though somewhat different, the population is tentatively placed as subsp. *feminalba* Sibatani and Grund.

**Introduction**

In the Irian Jaya (Indonesia)/Papua New Guinea region *Theclinesthes miskini* (T. P. Lucas) is represented by three subspecies: *arnoldi* (Fruhstorfer), 1916, with usually blue males and which is widely distributed in the Bismarck Archipelago and southern half of Papua New Guinea; *feminalba* Sibatani and Grund, 1978, with darker males and whitish females found on the eastern end of the north coast of Irian Jaya and on Manam and Karkar Islands, Papua New Guinea; and *brandti* Sibatani and Grund, 1978, with sparsely blue-scaled males and greyish-blue females from the Admiralty Islands, Papua New Guinea.

Here I record a population of this species from the Vogelkop area of Irian Jaya where the species has so far been unknown. It does not agree with any known subspecies exactly, but because of the very small number of available specimens I place it tentatively as subspecies *feminalba*. Below I describe the two sexes following the convention of Sibatani and Grund (1978).

***Theclinesthes miskini feminalba* Sibatani and Grund, 1978**

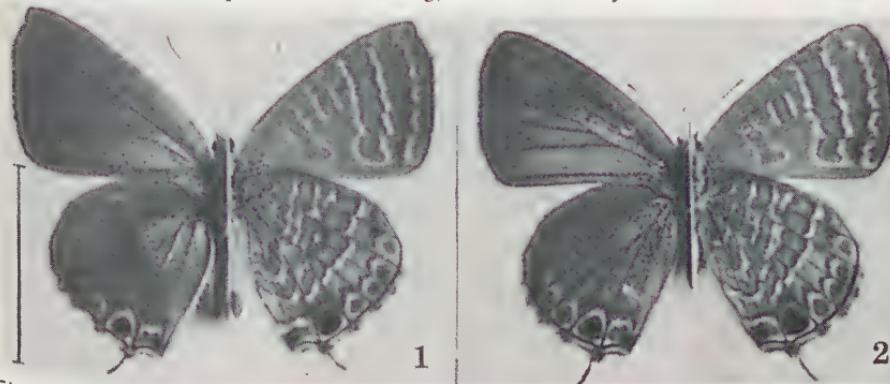
**Vogelkop population**

(Figs 1, 2)

**MATERIAL EXAMINED:** INDONESIA: Irian Jaya, north of Arfak Mountains, Warumare 150-600 m, 1 ♂, 1 ♀, 28.i.1974 (T. Nishizawa) in collection of A. Sibatani.

Male 13 mm (Fig. 1). Above dark brown; blue areas without violet tinge and limited to caudal half of proximal part of both wings; subterminal lunules in caudal half of hind wing; cilia white on fore wing, chequered on hind wing; otherwise similar to *feminalba* holotype.

Female 13 mm (Fig. 2). Above ground colour somewhat paler than in male; proximally dull greyish blue in caudal half of both wings; blue area distad extending beyond discocellular bar on fore wing, limited as in male on hind wing; cilia white, slightly dark at veins on fore wing, more clearly chequered on hind wing; otherwise as in *feminalba*.



Figs 1, 2. *Theclinesthes miskini feminalba* Sibatani and Grund, Vogelkop population; upper-side (left), underside (right). (1) ♂, (2) ♀. Scale: 1 cm.

## COMMENTS

The male differs from any known subspecies of *miskini* in its very restricted blue areas above. The dull blue colour of the female is rather similar to, but less extensive than, that of the female of subspecies *brandti*.

## Acknowledgements

I thank Mr T. Nishizawa, Tokyo, for his generous gift of the specimens and Mr D. P. Sands for critical reading of the manuscript.

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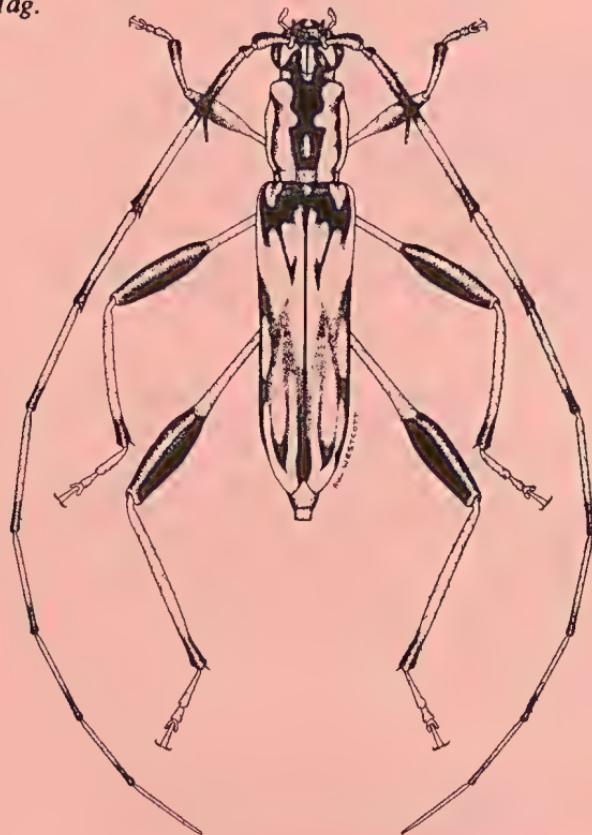
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Illustrated by Alan E. Westcott.

Depicts the citrus longicorn, *Skeletodes tetrops* Newman, the larvae of which are commonly found in decaying citrus wood in eastern New South Wales. Eggs are laid in dead bark, usually after damage by other longicorn species, and the larvae make shallow tunnels packed with flour-like frass. The species is not considered to be economically significant.

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## THE EARLY STAGES OF *ADALUMA URUMELIA* TINDALE AND *CANDALIDES GEMINUS* EDWARDS AND KERR (LEPIDOPTERA: LYCAENIDAE)

By E. D. Edwards

CSIRO Division of Entomology, P.O. Box 1700, Canberra City, A.C.T. 2601.

### Abstract

The early stages of *Adaluma urumelia* and *Candalides geminus* are briefly described and the generic relationships of the former discussed.

#### *Adaluma urumelia* Tindale

(Figs 1, 2, 4, 5)

*Egg.* Pale green; slightly flatter than hemispherical, with a depressed micropylar area; surface a complex pattern of pits and ridges with truncate projections where ridges intersect. Diameter 0.6 mm, height 0.3 mm. Two eggs preserved in the Australian National Insect Collection, tube No. 2879.

*Final instar larva* (Figs 1, 2). Head pale brownish green; thoracic and abdominal segments pale green, dorsal line darker green, three subdorsal lines cream, upper two angled laterally towards rear of each segment, lateral line cream; spiracles cream. Prothoracic and anal plates pale green, flattened and densely covered with short secondary setae. Dorsal and lateral surfaces of thorax and abdomen covered with short, colourless secondary setae; primary setae colourless, longer. Dorsal gland on abdominal segment 7 well developed, resembling a transverse line. Abdominal segment 8 with slightly raised projections bearing eversible organs. Length 14 mm. Two final instar larvae preserved in the Australian National Insect Collection, tube No. 2879.

*Pupa* (Figs 4, 5). Head, thorax and abdomen pale green or brown mottled with dark brown; spiracles pale brown. Head and abdomen flattened, with prominent lateral flanges; middorsal line raised, two short dorsal projections on thorax; surface of cuticle roughened and covered with minute raised dots. Attached to silken pad by anal hooks and central girdle. Length 11 mm, width 6 mm. Three pupae preserved in the Australian National Insect Collection, tube Nos. 2822 and 2881.

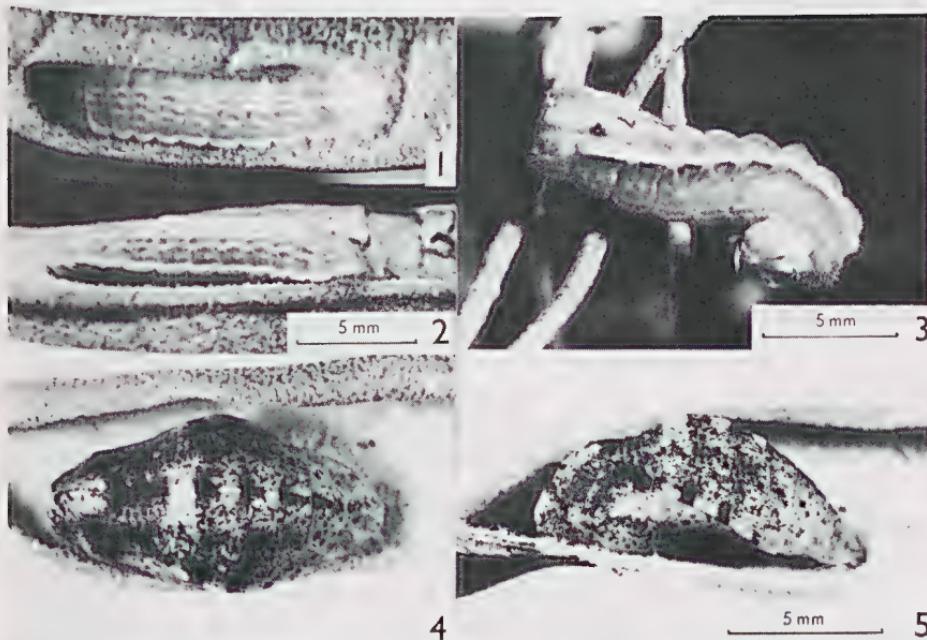
*Food plant.* *Boronia lanceolata* F. Muell. (Rutaceae).

#### COMMENTS

The early stages were collected in broken sandstone country at Nourlangie Creek, 8 km E of Mt Cahill, Northern Territory (coordinates 12°52'S, 132°47'E) in November 1972 and May 1973. Adults were collected at many sites within the catchments of the South and East Alligator Rivers in October, November, March, May and June and also near McArthur River Homestead, N.T. in October. Adults were probably present throughout the wet season (October to May).

Eggs were laid singly on the undersides of mature leaves, or on the petioles, of the food plant. Larvae rested and fed on the undersides of the leaves. Small black ants of the genus *Monomorium* attended the larvae but bushes invaded by green tree-ants [*Oecophylla smaragdina* (Fabricius)] lacked larvae. In May very pale empty pupal cases were plentiful, and a few green pupae were found on the undersides of mature leaves of the food plant. These were not found in the previous November which suggests that the pupal duration of these green pupae during the wet season was quite short. Larvae collected in late May and pupating in plastic bags in semi-darkness produced brown, mottled pupae. The pupal durations of two of these pupae were 220 and 310 days in the laboratory. It is possible that some, or all, larvae that become adults during the same wet season produce green pupae and pupate beneath living leaves on the food plant, while at the end of the wet season larvae pupate in sheltered situations off the food plant and adults do not emerge until the following wet season, from October onwards.

The larvae are more elongate than those of *Candalides xanthospilos* (Hübner) and similar in shape to those of *Nesolycaena albosericea* (Miskin) although less brightly coloured. The pupa is also very similar in shape to that of *N. albosericea* and both are slightly less flattened dorsoventrally than that of *C. xanthospilos*. The larvae of both *Adaluma* and *Nesolycaena* also feed on *Boronia*. The similarities in larval and pupal shape and in larval food plant support the close relationship of these two genera suggested by Sands (1971) and the form of the pupae clearly shows that they belong to the tribe Candalidini. However, it does not seem necessary to synonymise *Adaluma* and *Nesolycaena* if the division of *Candalides* sens. lat. into five genera by Tite (1963) is accepted. If, however, the genus *Candalides* is maintained in its broad sense the early stages and the larval food plant provide evidence that *Adaluma* should be synonymised with *Nesolycaena*. Nevertheless, as *Nesolycaena* was not studied by Tite (1963), a thorough evaluation of adult characters should be undertaken before reaching a decision.



Figs 1-5. (1, 2) dorsolateral and lateral views of final instar larva of *Adaluma urumelia* Tindale; (3) final instar larva of *Candalides geminus* Edwards and Kerr; (4, 5) dorsal and lateral views of pupa of *Adaluma urumelia* Tindale.

*Candalides geminus* Edwards and Kerr  
(Fig. 3)

**Egg.** Pale green when laid, soon becoming paler; dull white shortly before emergence. Flatter than hemispherical, with micropylar area depressed; surface with pattern of wide pits and ridges, slightly raised where ridges intersect. Diameter 0.7 mm, height 0.4 mm. One egg preserved in the Australian National Insect Collection, tube No. 2937.

**First instar larva.** Uniformly pale reddish brown. Head hidden by prothorax; thorax and abdomen with prominent primary setae.

**Final instar larva** (Fig. 3). Head green; thorax and abdomen green; dorsal line dark green; raised dorsal red spots on abdominal segments 1 and 6 (sometimes absent on 1); pale yellow subdorsal line on thoracic segments and abdominal segments 7 to 10, prominent on abdominal segments 1 to 6, white with yellow towards rear of each segment; subdorsal line bordered laterally on abdominal segments 1 to 6 by deep purple line (red in preserved larvae); lateral line pale yellow or absent; spiracles yellow. Prothoracic and anal plates green, flattened, covered with short secondary setae. Thorax and abdomen with primary setae short, brown on dorsal surface, colourless laterally; secondary setae colourless. Dorsal gland on abdominal segment 7 well developed, oval in shape. Areas

bearing eversible organs on abdominal segment 8 not raised. Length 15 mm. One larva preserved in the Australian National Insect Collection, tube No. 2938.

*Pupa.* Pale brownish yellow with scattered brown dots coalescing on dorsal line and wing margins to form dark markings; spiracles pale brown. Head and abdomen flattened and with prominent lateral flanges; middorsal line on head and abdomen raised; two short dorsal projections on thorax; surface of cuticle roughened and covered with minute raised dots. Attached to silken pad by anal hooks and central girdle. Length 13 mm, width 6 mm. One pupa preserved in the Australian National Insect Collection, tube No. 2938.

*Food plant.* *Cassytha paniculata* R.Br. (Cassythaceae).

#### COMMENTS

Larvae were reared from eggs collected 40 km ENE of Coonabarabran, N.S.W. (coordinates 31°07'S, 149°40'E) in October 1977.

Eggs were laid singly on the flower buds of the food plant. Ants were not present but may well attend the larvae. The larvae probably feed openly on the food plant during the day and pupate in sheltered situations nearby as do closely related species. They change colour to brown or reddish brown prior to pupation. Several eggs were parasitised by a wasp of the family Scelionidae. In the laboratory, at about 22°C, eggs hatched after approximately 10 days, the larval stage lasted 22 days and the pupal stage 13 days. The species probably has a rapid succession of generations during the spring, summer and autumn in the southern parts of its range.

The larva is very similar in shape to that of *Candalides hyacinthinus* (Semper) and *C. erinus* (Fabricius) but is more brightly coloured than is usual in these species. The pupa is very similar in shape to that of *C. erinus*.

#### Acknowledgements

Thanks are due to Mr L. G. Adams and Mrs E. D'Arnay for identifying the food plants, Miss J. C. Cardale for identifying the parasite, Dr R. W. Taylor for identifying the ant and Mr J. P. Green for making black and white prints from colour transparencies and the photographs of the pupa.

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## REVIEW OF THE AUSTRALIAN GENERA *EURYPHANTIA* KIRKALDY AND *THANATOCHLAMYS* KIRKALDY (HOMOPTERA, FULGOROIDEA, FLATIDAE)

By M. J. Fletcher

Biological and Chemical Research Institute, P.M.B. 10, Rydalmerc, N.S.W., 2116.

### Abstract

*Thanatochlamys* Kirkaldy is synonymized with *Euryphantia* Kirkaldy on the basis of the extreme similarity between their two type species. The species are separable only by comparison of male genitalia and, apparently, by their allopatric distributions. *E. cinerascens* Kirk. is widespread in Queensland and Northern Territory but does not extend into the eastern coast of Cape York Peninsula to which area *E. tristis* (Kirk.) is restricted. The male genitalia of both species are described and figured.

### Introduction

*Euryphantia* Kirkaldy (1906) and *Thanatochlamys* Kirkaldy (1907) were each erected to contain a single species. No further species have been added to either genus.

The genitalia of 39 males of what was thought to be *Euryphantia cinerascens* Kirkaldy, were examined and found to exist in two forms. The distributions of these two forms revealed that one form was restricted to the Cairns district and eastern coast of Cape York Peninsula, Queensland, whereas the other form was found in the Brisbane area, at Bundaberg, Palm Island near Townsville, and Carnarvon Gorge, all in Queensland, and near Mudginbarry HS in the Northern Territory. This second form has not been recorded north of 18°S latitude in Queensland, although two specimens were collected at 12°31'S latitude in the Northern Territory.

Despite extensive investigation no consistent morphological difference, except in the male genitalia, has been found between the two groups. Consequently the females can be identified only by reference to their collection locality.

The male holotype of *Thanatochlamys tristis* Kirkaldy from Cairns was examined and proved to be identical to the form from North Queensland. The holotype of *E. cinerascens* is a female from Bundaberg, Queensland. This locality places it well outside the range of the species in north Queensland.

Hence the northern Queensland form is *T. tristis* and the more widespread form *E. cinerascens*. Since the two species are separated reliably only on male genitalia they are certainly congeneric. The two genera are here synonymised, *Euryphantia* Kirkaldy having priority.

### *Euryphantia* (Kirkaldy) 1906

*Euryphantia* Kirkaldy (1906). *Bull. Haw. Sug. Pl. Ass. Div. Ent.* 1(9): 456.

*Thanatochlamys* Kirkaldy (1907). *Bull. Haw. Sug. Pl. Ass. Div. Ent.* 3: 101. New synonym. Type species by monotypy, *E. cinerascens* Kirkaldy.

The genus was adequately characterised in the original description, the characters of principal importance being the three sharp frontal carinae meeting at the sharp apex of the frons, the flat vertex with angulate front margin and

median longitudinal carina which continues through the pronotum and mesonotum. The presence of only one forked longitudinal vein in the basal half of the tegmen, this being the cubital, was pointed out by Kirkaldy, but several specimens have other longitudinal veins forking at or slightly distal to the midlength of the tegmen. The brown colouration would also appear to be of generic significance since all species of related genera such as *Euphanta* Melichar, are basically green.

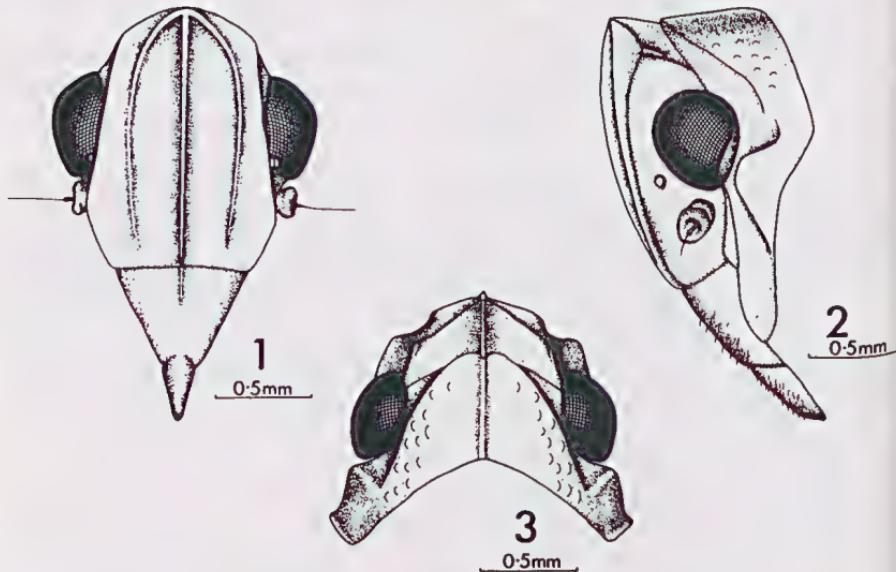
*Euryphantia cinerascens* Kirkaldy 1906

**Type:** Holotype ♀ (seen), Bundaberg, Queensland, June 1904. Type location: Bernice P. Bishop Museum, Honolulu.

**Known distribution:** NORTHERN TERRITORY: 9 km N by E of Mudginbarry HS; Groote Eylandt. QUEENSLAND: Albert River; Carnarvon Gorge; Mt. Edwards; Brisbane metropolitan area; Gatton; Bundamba; Dalby; Palm Island; Bundaberg.

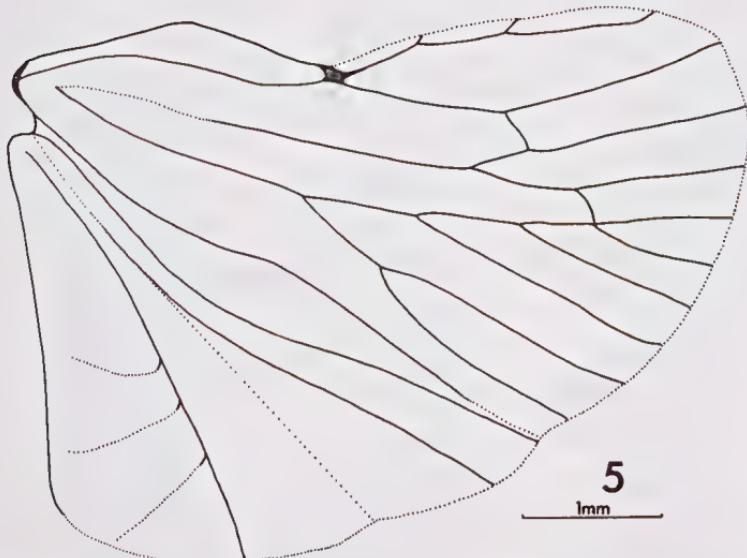
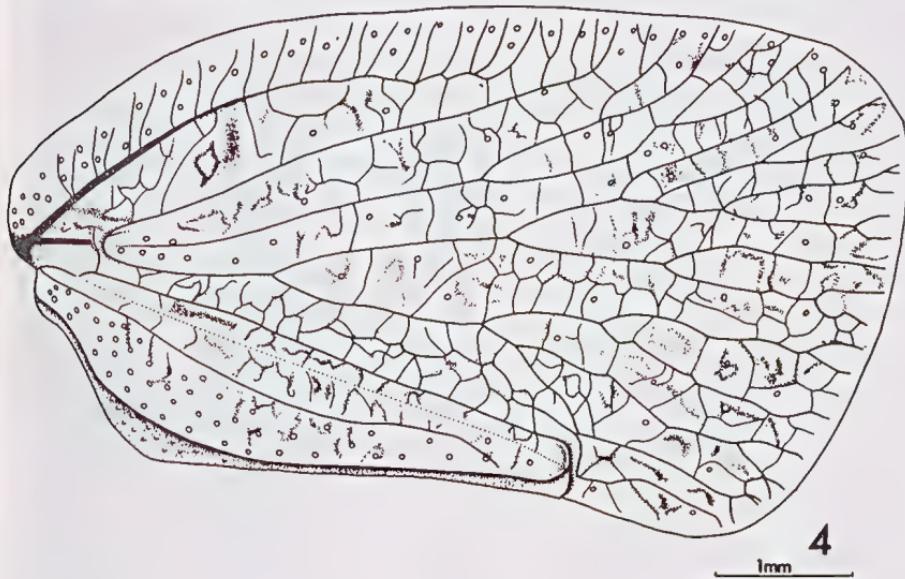
**Description:** See Kirkaldy (1906: 456) and Figs 1-8. Table 1 lists measurements of females and Table 2 of males.

**Male genitalia:** Pygofer with broad rounded lateral lobe from posterior margin. Anal segment short, not reaching as far posteriorly as subgenital plates, emarginate distally and produced ventrally short distance at base. Subgenital plates broad, convex, rounded posteriorly and ventrally, truncate posterodorsally with short broad point at dorsal corner. Aedeagus very broad with four sets of appendages; one near base on dorsal side, short, curved anteriorly and pointed, second set at apex of dorsal edge, also curved anteriorly and sharply pointed, third set midway between these curving dorsally and fourth set large,



Figs 1-3. *E. cinerascens*, head and pronotum. (1) frontal view; (2) lateral view; (3) dorsal view. Specimen illustrated: ♂ from Bundaberg, Qld.

from lateral part of conjunctiva near apex, curving ventrally and apically recurved towards posteriorly end and clubbed. In addition, a short clubbed projection extends posteriorly from near base of this fourth set of appendages. The lengths and proportions of these various sets of appendages varies slightly with locality but the basic arrangement remains the same.



Figs 4-5. *E. cinerascens*. (4) tegmen; (5) hind wing. Specimen illustrated: ♂ from Virginia, near Brisbane, Qld.

***Euryphantia tristis* (Kirkaldy) 1907, new combination***Thanatochlamys tristis* Kirkaldy (1907). Bull. Haw. Sug. Pl. Ass. Div. Ent. 3: 1-186.

Type: Holotype ♂ (seen), Cairns, Queensland, July 1904. Type location: Bernice P. Bishop Museum, Honolulu.

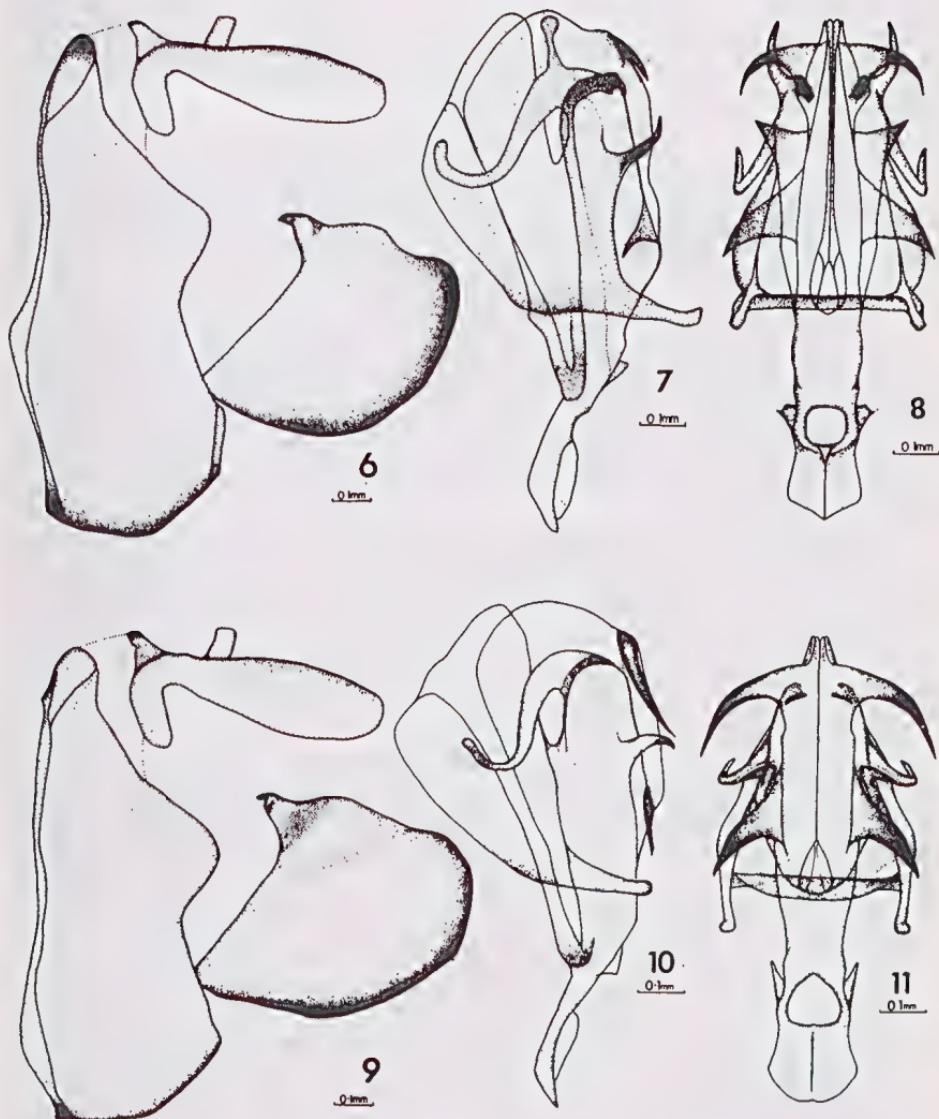
Known distribution: NORTH QUEENSLAND: Rocky River; Kuranda-Mareeba road; Gordonvale; Meringa.

Description: See Kirkaldy (1907: 101) and Figs 9-11. The morphology of the head is not sufficiently different to that of *E. cinerascens* to warrant illustration. Table 1 lists measurements of females and Table 2 of males.TABLE 1  
Measurements (range and mean) of adult females of *E. cinerascens* and *E. tristis*

	<i>E. cinerascens</i> Northern Territory (n = 8)	<i>E. cinerascens</i> Queensland (n = 12)	<i>E. cinerascens</i> All areas (n = 20)	<i>E. tristis</i> All areas (n = 3)
tegmen length	7.27-8.15 (7.65)	7.27-8.08 (7.75)	7.27-8.15 (7.71)	7.58-7.73 (7.66)
clavus length	4.65-5.15 (4.89)	4.75-5.25 (5.03)	4.65-5.25 (4.97)	4.85-5.05 (4.95)
costal cell length	4.09-4.80 (4.47)	4.14-4.80 (4.47)	4.09-4.80 (4.47)	4.24-4.65 (4.48)
costal area width	0.44-0.53 (0.48)	0.48-0.61 (0.55)	0.44-0.61 (0.53)	0.48-0.53 (0.51)
costal cell width	0.53-0.62 (0.59)	0.53-0.65 (0.60)	0.53-0.65 (0.59)	0.57-0.63 (0.59)
vertex length	0.28-0.32 (0.30)	0.32-0.44 (0.37)	0.28-0.44 (0.34)	0.32-0.36 (0.33)
vertex width	0.89-0.97 (0.92)	0.89-0.97 (0.93)	0.89-0.97 (0.93)	0.87-0.93 (0.90)
pronotum length	0.50-0.53 (0.52)	0.44-0.61 (0.53)	0.44-0.61 (0.53)	0.44-0.53 (0.49)
mesonotum length	1.62-1.78 (1.69)	1.58-1.78 (1.69)	1.58-1.78 (1.69)	1.64-1.70 (1.66)
mesonotum width	1.41-1.58 (1.52)	1.41-1.70 (1.59)	1.41-1.70 (1.56)	1.45-1.62 (1.52)
frons length	1.25-1.37 (1.31)	1.29-1.50 (1.41)	1.25-1.50 (1.37)	1.37-1.39 (1.38)
frons width	1.00-1.10 (1.05)	1.01-1.16 (1.06)	1.00-1.16 (1.06)	1.01-1.13 (1.08)
fore tibia length	1.17-1.29 (1.22)	1.13-1.33 (1.27)	1.13-1.33 (1.25)	1.21-1.29 (1.25)
mid tibia length	1.21-1.37 (1.29)	1.21-1.41 (1.30)	1.21-1.41 (1.30)	1.21-1.29 (1.25)
hind tibia length	1.66-2.02 (1.84)	1.78-2.22 (1.93)	1.66-2.22 (1.90)	1.90-1.94 (1.91)

TABLE 2  
Measurements (range and mean) of adult males  
of *E. cinerascens* and *E. tristis*

	<i>E. cinerascens</i> (n = 20)	<i>E. tristis</i> (n = 5)
tegmen length	6.26-7.27 (6.74)	5.96-6.57 (6.35)
clavus length	4.14-4.80 (4.42)	3.84-4.55 (4.21)
costal cell length	4.24-5.00 (4.53)	4.04-4.65 (4.32)
costal area width	0.40-0.61 (0.50)	0.38-0.53 (0.44)
costal cell width	0.46-0.59 (0.54)	0.51-0.61 (0.54)
vertex length	0.16-0.32 (0.25)	0.24-0.32 (0.30)
vertex width	0.71-0.89 (0.80)	0.79-0.85 (0.82)
pronotum length	0.40-0.55 (0.48)	0.40-0.46 (0.44)
mesonotum length	1.33-1.68 (1.51)	1.41-1.58 (1.48)
mesonotum width	1.29-1.56 (1.44)	1.21-1.33 (1.28)
frons length	1.21-1.37 (1.29)	1.21-1.29 (1.26)
frons width	0.91-1.05 (0.98)	0.91-1.01 (0.96)
fore tibia length	1.09-1.29 (1.20)	1.03-1.21 (1.14)
mid tibia length	1.17-1.33 (1.24)	1.09-1.29 (1.21)
hind tibia length	1.62-1.90 (1.74)	1.58-1.86 (1.66)



Figs 6-11. ♂ genitalia. (6-8) *E. cinerascens*, ♂ from Bundaberg, Qld.: (6) lateral external view; (7) aedeagus, lateral view; (8) aedeagus, antero-dorsal view. (9-11) *E. tristis*, ♂ from junction of Goldmine and Davies Cks, Kuranda-Mareeba rd, N. Qld.: (9) lateral external view; (10) aedeagus, lateral view; (11) aedeagus, antero-dorsal view.

*Male genitalia:* Pygofer, anal segment and subgenital plates similar to those of *E. cinerascens*. Aedeagus similar to that of *E. cinerascens* except for the following points. Second pair of processes, from apex of dorsal edge, long, reaching to level of third pair which curve antero-dorsally rather than dorsally. First pair slightly sinuate towards apex. Fourth pair lacking clubbed posterior projection from near base.

### Discussion

The differences between the various lists in Table 1 imply that the sizes of the individuals making up the various populations are environmentally rather than genetically controlled. This is indicated by the fact that the two forms of *E. cinerascens* from Northern Territory and Queensland differ as much from each other in size as they do from *E. tristis*.

As is the case with many other fulgoroid groups (see Kramer 1976, 1977, Evans 1966) the two species of *Euryphantia* are reliably differentiated only by reference to the male genitalia. Since the two species have allopatric distributions it is also possible to ally specimens with one or other of the species if the collection data are known. Females can only be identified by reference to their collection locality.

Kirkaldy obviously considered the possibility of the synonymy since one specimen from Gordonvale, North Queensland (*E. tristis* according to this locality) in the Bishop Museum collection is labelled, in Kirkaldy's handwriting, "*Euryphantia cinerascens* Kirk. = *Thanatochlamys tristis* Kirk." (J. T. Medler, pers. comm.). Due to the choice of material Kirkaldy used for the original description the two species are valid despite the generic synonymy.

### Acknowledgements

I thank Dr G. M. Nishida, Bernice P. Bishop Museum, Honolulu, for the loans of the types of the two species and Dr J. T. Medler of the same Museum for pointing out Kirkaldy's apparent realization of the synonymy. I also thank Dr D. K. McAlpine (Australian Museum, Sydney), Mr T. G. Weir (A.N.I.C., Canberra), Dr T. E. Woodward (University of Queensland) and Dr G. B. Monteith (Queensland Museum) for the loan of specimens used in this study.

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## THE STATUS OF THE GENERA *ATROPHANEURA* REAKIRT AND *PACHLIOPTA* REAKIRT (LEPIDOPTERA: PAPILIONIDAE)

By D. L. Hancock

Department of Entomology, University of Queensland, St. Lucia 4067\*

### Abstract

The *Pachliopta polydorus* group of swallowtails is shown to be closely related to the *Atrophaneura coon* group. The relationship between these two groups and other species of *Atrophaneura* is such that recognition of *Pachliopta* and *Atrophaneura* as separate genera results in a paraphyletic classification. *Pachliopta* Reakirt is thus reinstated as a synonym of *Atrophaneura* Reakirt. *Atrophaneura* is shown to be distinct from *Parides* Hübner at the generic level.

### Introduction

Since Munroe (1961) published his classification of the Papilionidae, various generic names have been applied to the *polydorus* group of Indo-Australian, *Aristolochia*-feeding swallowtails. The oldest of these, *Polydorus* Swainson, 1833, is a junior homonym of *Polydorus* Blainville, 1826, and is therefore unavailable. *Atrophaneura* Reakirt, 1865, placed as a subgenus of *Parides* Hübner, 1819 by Munroe, and *Pachliopta* Reakirt, 1865, separated (as *Pachlioptera*) by Munroe from his *Parides-Atrophaneura* assemblage, have both been widely used. As currently recognised, *Pachliopta* is restricted to the *polydorus* group, whilst *Atrophaneura* comprises the *antenor*, *latreillei*, *nox* and *coon* groups. The status of these two generic names is discussed below.

### Materials

Of the 43 species currently placed in the genera *Atrophaneura* and *Pachliopta*, 17 were examined in the present study. Of these, 12 were dissected for male genitalic characters, viz. *A. alcinous*, *A. dasarada*, *A. polyuectes*, *A. priapus*, *A. horishanus*, *A. aidoneus*, *A. nox*, *A. coon*, *P. hector*, *P. polyphontes*, *P. aristolochiae* and *P. polydorus*. Male genitalia of a further 14 species were examined from published illustrations (Corbet, 1948; Jordan, 1915, 1928). In addition, 24 species of *Parides* were examined. Nine of these, encompassing all three species groups, were dissected.

### Discussion

#### *Pachliopta* Reakirt

Munroe (1961) separated this genus from *Atrophaneura* largely on the basis of differences in the genitalia. As Munroe noted, in *Pachliopta* the female ductus bursae is heavily sclerotized whilst in the male the valve is greatly reduced and the socii and tegumen hypertrophied and heavily sclerotized. However, these characteristics merely represent specializations at the group level, a fact that can be appreciated when the male genitalia of species in the *polydorus* group are compared with various species of *Atrophaneura* (Figs 1-9). The evolution of these genitalic characteristics can be traced as follows:—

In primitive groups, such as *antenor* and *latreillei* (Fig. 1) the valve is entire and somewhat ovate. In the *nox* group (Figs 2-4) the valve is dorso-apically emarginate; there is also a tendency towards a dorso-basal reduction. In the *coon* group (Fig. 5) the valve is again emarginate, both dorsally and, to a lesser extent, distally. Unlike the *nox* group, there is no dorso-basal reduction and the emarginations in these two groups appear to have

\* Present address: Plant Protection Res. Inst., P.O. Box 8100, Causeway, Salisbury, Rhodesia.

evolved separately. In the *polydorus* group (Figs 6-9) the trend seen in *coon* is taken further with a great reduction of the valve. The extent of this reduction varies; in *polyphontes* the existance of the dorsal emargination is shown by retention of the dorso-basal part of the valve, as seen in *coon*; in *aristolochiae* and *polydorus* this dorso-basal portion is absent in *hector* the valve is further reduced to a small basal part only.

#### *clasper*

In the *antenor*, *latreillei* and *nox* groups (Figs 1-4) the clasper is broad and either smooth, serrate or toothed. In the *coon* group (Fig. 5) the clasper is reduced to a narrow elongate and pointed structure. In the *polydorus* group (Figs 6-9) the clasper is also narrow and pointed, although much shorter than in *coon*; it is longest in *hector* and shortest in *aristolochiae* and *polydorus*.

#### *aedeagus*

In *antenor* the aedeagus is long, slender and straight. In the *latreillei* and *nox* groups (Figs 1-4) it is short, thick and strongly curved. In the *coon* group (Fig. 5) it is long slender and weakly curved. In the *polydorus* group (Figs 6-9) the aedeagus is again long slender and weakly curved, especially so in *hector*.

#### *tegumen and socii*

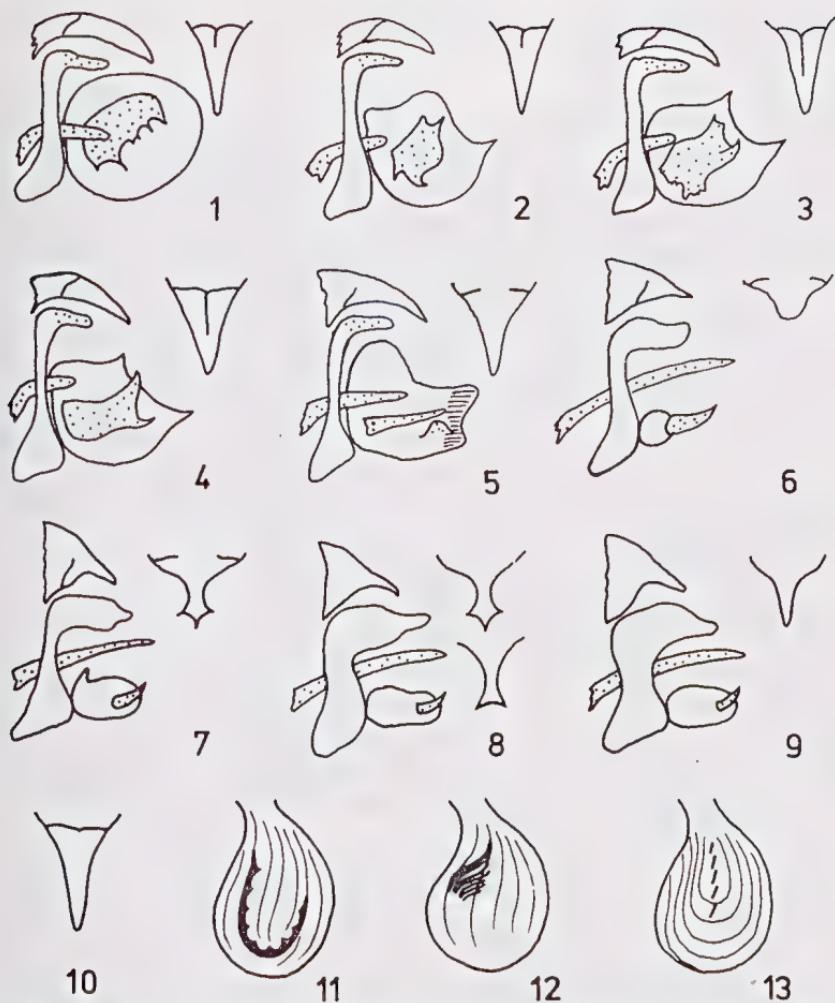
In the *antenor*, *latreillei*, *nox* and *coon* groups (Figs 1-5) the tegumen and socii are unmodified. In the *polydorus* group (Figs 6-9) these structures are greatly enlarged and heavily sclerotized. This modification becomes progressively greater from *hector* to *polyphontes* to *aristolochiae* and *polydorus*.

#### *pseuduncus and 8th tergite*

In *antenor* the pseuduncus is absent. In the *latreillei* and *nox* groups (Figs 1-4) it is separated from a narrow 8th tergite by a complete suture, this suture extending for a distance down the mid-line of the pseuduncus. In the *coon* group (Fig. 5) the pseuduncus is separated from a relatively broad 8th tergite by an incomplete suture, being fused medially. In the *polydorus* group (Figs 6-9) the pseuduncus is either separated from a broad (*hector*) to very broad (*polyphontes*) 8th tergite by an incomplete suture, being fused medially as in *coon*, or is fused completely to a very broad 8th tergite (*aristolochiae* and *polydorus*).

Munroe (1961) also indicated that the immature stages served to differentiate *Pachliopta* from *Atrophaneura*. However, this is not the case. The larva is similar in all groups, when mature being dark with rows of dorsal and lateral tubercles, these often red or red-tipped, or with some of the tubercles white. Mature larvae in the *latreillei*, *nox* and *coon* groups have a white transverse band on abdominal segments 3-4 (band absent in some *nox* group species, e.g. *semperi*, *kuehni*). In the *polydorus* group this band is reduced. In *hector* it is present as a series of spots on segments 3-4; in most (e.g. *jophon*, *polyphontes*, *mariae*, *phegeus*, *aristolochiae*) it is present as a band confined to segment 3; in others (e.g. *liris*, *polydorus*) it is absent. The pupa is also similar in all groups, having well developed lateral carinae and paired, dorsal lobe-like processes on abdominal segments 4 to 7 (Mell, 1938; Talbot, 1939; Straatman and Nieuwenhuis, 1961; Igarashi, 1966; Jumalon, 1968; Straatman, 1968; Munshi and Moiz, 1968, 1969; D'Abra, 1971; Common and Waterhouse, 1972).

Thus characters of the male genitalia and immature stages do not serve to distinguish the *polydorus* group from other species of *Atrophaneura* at the generic level. On characters of the valve, clasper, aedeagus and pseuduncus/8th tergite the affinities of the *polydorus* group are clearly with the *Atrophaneura coon* group. Specialised characters such as the hypertrophied socii and tegumen



Figs 1-13. Male and female genitalia. (1-9) male genitalia of *Atrophaneura*: lateral view (with left valve removed) and dorsal view of pseuduncus: (1) *A. elcinous*; (2) *A. priapus*; (3) *A. horishanus*; (4) *A. nox*; (5) *A. coon*; (6) *A. hector*; (7) *A. polyphontes*; (8) *A. aristolochiae*; (9) *A. polydorus*. (10) dorsal view of pseuduncus of *Parides*. (11-13) female bursa and signum of: (11) *Parides aglaope*; (12) *Atrophaneura polydorus*; (13) *Troides priamus euphorion*.

and the sclerotised female ductus bursae serve to separate these taxa at the group level only. The *coon* and *polydorus* groups form a pair of sister-groups, as do the *latreillei* and *nox* groups, the latter united by the nature of the clasper, aedeagus and pseuduncus/8th tergite. *A. antenor* stands somewhat apart from the other groups. Thus, recognition of *Pachliopta* as a genus results in the necessity of recognising separate genera for the *coon*, *antenor* and *latreillei-nox* groups, to avoid paraphyly. *Pachliopta* and *Atrophaneura* should therefore be synonymized. Both generic names appeared in the same publication (Reakirt, 1865); Hemming (1964) accorded precedence to *Atrophaneura*,

following the arrangement of Corbet (1943). *Pachliopta* is thus reinstated as a synonym of *Atrophaneura*.

#### *Atrophaneura* Reakirt

Munroe (1961) placed *Atrophaneura* as a subgenus of *Parides* Hübner, uniting them on characters of male genitalia and immature stages. Fundamentally the male genitalia of the two genera are similar; however they differ in one essential feature. In *Atrophaneura*, as in *Parides*, a suture separates the pseuduncus from the 8th tergite, but in *Parides* this suture does not extend down the mid-line of the pseuduncus (Fig. 10), as it does in all species of *Atrophaneura* where the suture is medially present. The *Parides* type of suture is seen also in *Euryades* C. & R. Felder and *Cressida* Swainson; the *Atrophaneura* type is seen also in *Troides* (*Troides*) and *Troides* (*Ornithoptera*), the suture being absent in *Troides* (*Trogonoptera*). The type of suture present is consistent for all species examined in their respective groups and the mid-line extension illustrates a close relationship between *Atrophaneura* and *Troides* Hübner, serving to separate these two genera from the more primitive *Euryades*, *Cressida* and *Parides*.

Additionally, *Parides* and *Atrophaneura* can be distinguished by the female bursa copulatrix. In *Parides* the signum is V-shaped (Fig. 11), whereas in *Atrophaneura* the signum is ribbon-like (Fig. 12).

*Parides* and *Atrophaneura* cannot be regarded as congeneric as this results in paraphyly, *Atrophaneura* being more closely related to *Troides* than to *Parides*. Talbot (1939) had earlier noted the close morphological relationship between *Atrophaneura* and *Troides* and this, coupled with zoogeographic evidence (*Atrophaneura* and *Troides* being Indo-Australian, *Parides* South American), supports the above arrangement.

#### Phylogeny

All three genera of Indo-Australian Troidini—*Cressida*, *Atrophaneura* and *Troides*—are derivable from the more primitive South American *Euryades* and *Parides*, and represent a dual invasion before the break-up of Gondwanaland. Present day distribution patterns suggest that the two invading ancestors, *Cressida* and *Atrophaneura/Troides*, followed different dispersal routes. *Cressida* followed the more usual route, to Australia [c.f. *Protographium leosthenes* (Doubleday) and *Papilio anactus* W. S. Macleay], whilst the *Atrophaneura/Troides* ancestor appears to have dispersed via India (as *Atrophaneura*) to South-East Asia (as *Troides*). This supports the suggestion by Ridd (1971) that India and South-East Asia were closely associated as part of Gondwanaland. The presence of *A. antenor* on Madagascar, the only troidine in the Ethiopian region, supports the suggestion that dispersal was via India. With the post-Gondwanan unification of India and Asia, *Atrophaneura* was able to radiate throughout the Indo-Australian region, the most easterly representatives belonging to the specialised *polydorus* group.

#### Classification

Five species groups of *Atrophaneura* are recognizable. The characters of *A. antenor*, coupled with its geographical distribution, support the recognition

of a subgenus for this species. The genus and subgenera are characterised below; for group characteristics see Munroe (1961).

### Genus *Atrophaneura* Reakirt 1865

Type species: *Atrophaneura erythrosoma* Reakirt, 1865 (= *Papilio semperi* C. & R. Felder, 1861).

A genus in the Troidini, closest to *Parides* and *Troides* s.l. Differs from *Parides* in the better developed sinus of the fifth tarsal segment; in the absence of anthoxanthins from all species (Ford, 1944); in the pseuduncus/8th tergite suture, when present medially, extending down the mid-line of the pseuduncus; and in the ribbon-shaped, rather than V-shaped, female signum. Differs from *Troides* in vein  $R_2$  of the fore wing arising from a point opposite  $CuA_1$  rather than  $CuA_2$ ; in the absence of any form of yellow, fluorescent pigment; in having a normally suspended pupa; and in the distinct female signum, reduced to spicules in *Troides* (Fig. 13).

### Subgenus *Pharmacophagus* Haase, 1892

*Pharmacophagus* Haase, 1892, *Bibl. Zool.* 8: 15. Type species: *Papilio antenor* Drury, 1773.

Fore wing with submarginal white spots; fore wing intercalary folds not darker-scaled than rest of wing; fore and hind wings with marginal white spots; antennae red; antennal club straight; male genitalia with pseuduncus absent beyond suture.

One species: *antenor* (Drury).

### Subgenus *Atrophaneura* Reakirt, 1865

*Polydorus* Swainson, 1833, *Zool. Illust.* (2)3: pl. 101, nec Blainville, 1826. Type species *Polydorus thoas* Swainson.

*Atrophaneura* Reakirt, 1865, *Proc. ent. Soc. Philad.* 3: 446. Type species *Atrophaneura erythrosoma* Reakirt.

*Pachliopta* Reakirt, 1865, *Proc. ent. Soc. Philad.* 3: 503. Type species *Papilio diphilus* Esper.

*Pachlioptera* Scudder, 1875, *Proc. Amer. Acad. Arts Sci., Boston* 10: 235. Incorrect spelling of *Pachliopta*, same type species.

*Byasa* Moore, 1882, *Proc. zool. Soc. Lond.* 1882: 258. Type species *Papilio philoxenus* G. R. Gray.

*Panosmia* Wood-Mason & de Niceville, 1886, *Jl. Asiat. Soc. Bengal* 55: 374. Type species *Papilio dasarada* Moore.

*Pangerana* Moore, 1886, *Jl. Linn. Soc. Lond.* 21: 51. Type species *Papilio varuna* White.

*Tros* Kirby, 1896, in *Allen's Nat. Libr. Hand-book Lepid.* 2: 305. Type species *Papilio hector* Linnaeus.

*Karanga* Moore, 1902, *Lepidoptera Indica* 5: 157. Type species *Papilio nox* Swainson.

*Losaria* Moore, 1902, *Lepidoptera Indica* 5: 184. Type species *Papilio coon* Fabricius.

*Balignina* Moore, 1902, *Lepidoptera Indica* 5: 187. Type species *Papilio neptunus* Guérin-Méneville.

Fore wing without submarginal white spots; fore wing intercalary folds darker scaled than rest of wing, paler along veins; fore and hind wings without marginal white spots (fringe hairs white in *hector*); antennae black; antennal club curved; male genitalia with pseuduncus present.

Forty-two species in four groups:

(i) *latreillei* group (14 species): *daemonius* (Alpheraky), *plutonius* (Oberthür), *alcinous* (Klug), *latreillei* (Donovan), *polla* (de Niceville), *crassipes* (Oberthür), *adamsoni* (Grose-

Smith), *nevilli* (Wood-Mason), *laos* (Riley and Godfrey), *mencius* (C. & R. Felder), *impediens* (Rothschild), *hedistus* (Jordan), *dasarada* (Moore), *polyeuctes* (Doubleday) [= *philoxenus* (Gray)].

(ii) *nox* group (12 species): *semperi* (C. & R. Felder), *kuehni* (Honrath), *luchti* (Roepke), *hageni* (Rogenhofer), *priapus* (Boisduval), *sycorax* (Grose-Smith), *horishanus* (Matsumura) [= *sauteri* (Heyne)], *aidoneus* (Doubleday), *varuna* (White), *zaleucus* (Hewitson), *nox* (Swainson), *dixoni* (Grose-Smith).

(iii) *coon* group (3 species): *neptunus* (Guérin-Méneville), *coon* (Fabricius), *rhodifer* (Butler).

(iv) *polydorus* group (13 species): *hector* (Linnaeus), *jophon* (Gray), *pandiyana* (Moore), *oreon* (Doherty), *liris* (Godart), *polyphontes* (Boisduval), *schadenbergi* (Semper), *mariae* (Semper), *phegeus* (Hopffer), *phlegon* (C. & R. Felder) [= *annae* (C. & R. Felder), = *strandi* (Bryk), = *sabinae* (Seyer)], *atropos* (Staudinger), *aristolochiae* (Fabricius), *polydorus* (Linnaeus).

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## C. G. L. GOODING, 1896-1980

On 12 January, 1980, Mr Charles George Llewellyn Gooding of Warragul, Victoria, died at the age of 83. One of Australia's best known amateur entomologists, Llew Gooding was born near Moe, Victoria, on 9 September, 1896, one of a family of ten children, and lived throughout his long life in Gippsland. In 1926 he married Hilda Nadenbausch and the couple had one daughter, Mrs Margaret Coulson of Traralgon. He became a very successful dairy farmer in the Moe district and, despite serious setbacks caused by the 1934 drought and the 1939 bushfires, built up a valuable stud herd of Australian Illawarra Shorthorn cattle which he ran on his property "Riversleigh Park". Upon retirement in 1954 he built a home in Warragul.

As a young man Llew Gooding began what was to become a superb collection of Lepidoptera and Coleoptera, much of which was collected in Gippsland before the region was extensively cleared for agriculture or devoted to open-cut mining and associated industrial and urban development. His early collecting was done on foot or on horseback and it was not until 1928 that he was able to utilise a motorcar for transport. Throughout his life he had the unfailing support of his wife, Hilda.

Over the years his collection was greatly amplified by exchanging specimens with many well known collectors in Australia and overseas. His Australian entomological correspondence began in 1917 with George Lyell and he continued corresponding with many such collectors throughout his life. His overseas correspondents included some in Britain, Germany, Czechoslovakia, Norway, Sweden, Russia, Spain, Argentina, California and Japan, and he also had contacts at various missions in India, China, Taiwan and the Pacific islands.

Llew Gooding specialized in collecting the Hepialidae, a family of primitive moths for which Australia is noted, and worked closely with Dr N. B. Tindale who described many species based on specimens collected by Gooding in the Moe district. Tindale's association with Gooding extended over a period of some 50 years and included several memorable visits to the Gooding property. Their friendship began on a showery afternoon in February 1929, at the peak of the emergence period of several Gippsland hepialids, when Gooding met Tindale at the Moe railway station with his wagon and, during the leisurely trip to "Riversleigh Park", pointed out hundreds of newly emerged hepialid moths hanging from the shrubs and tree trunks. The contribution made by the Goodings to our knowledge of the Hepialidae was recorded in 1935 and 1956 when Tindale named two species discovered near Moe as *Oxycanus goodingi* and *O. hildae* respectively. Tindale again honoured Gooding in 1965 when he described the lycaenid butterfly *Holochila goodingi* (now *Candalides consimilis goodingi*), some of the original specimens of which were from the Gooding collection.

Not only was Llew Gooding an energetic and devoted collector, but he took a special pride in mounting and labelling his specimens meticulously; at times he was moved to reprimand those who sent him inferior or poorly mounted specimens. He was also an accomplished cabinetmaker and constructed all of the 800 store boxes which lined the collection room at his Warragul home. More than 100 store boxes contained his Australian Hepialidae and another 300 boxes his collection of Australian butterflies and other moths. His Coleoptera were contained in about 100 boxes, about one-third of which were Buprestidae, a family in which he took a special interest. The remainder of his collection was exotic Lepidoptera, including examples of many rare species of the *Argynnis* group of genera. In January 1979, when he felt he could no longer maintain his valuable collection to his satisfaction, Llew Gooding donated it to the Commonwealth, and it is now part of the Australian National Insect Collection at Canberra.

Llew Gooding was a respected member of the Masonic Lodge, an office bearer in the Presbyterian Church, and a member of the Country Party for more than 50 years. He was also a keen gardener. For many years he was actively involved in the Latrobe Valley Naturalists' Club and published nine papers on Gippsland butterflies and moths in the *Latrobe Valley Naturalist* between 1968 and 1977, some of which were reprinted in the *Victorian Entomologist*. During the 1930's he provided assistance to G. F. Hill in his field experiments

for CSIR on the control of the underground grass grub, *Oncopera* spp., native hepialid pests of pastures. He was the first person to recognise in 1937 the presence of the cabbage white butterfly *Pieris rapae* in Victoria, two years before its establishment was accepted officially. He was also responsible for the only observations on the life history of *Acrôdipsa cuprea*, a small lycaenid butterfly with larvae predacious on ants.

In the Queen's New Year Honours List of 1980, shortly before his death, Lieut Gooding was awarded the MBE, for his contributions to entomology, a fitting reward for a lifetime devoted to the collection and study of insects.

I. F. B. COMMON and M. S. UPTON

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## BOOK REVIEW

*Collecting, preserving and classifying insects* by E. C. Dahms, Geoff Monteith and Sybil Monteith. 1979. Queensland Museum Booklet No. 13. 32 pages, 21 x 15 cm, illustr. Price 75c.

This text is designed primarily for secondary school students, although it would be useful to anyone wishing to begin their own insect collection.

The first half of the booklet discusses the equipment and procedures used in collecting and preserving. These subjects are well covered and provide the beginner with an accurate and basic knowledge. The text is easily read and the illustrations more than adequate.

The remaining half concerns insect classification. Here the text can be divided into three main sections: an introductory section, a description of each order occurring in Australia, and a key to the orders of larger insects. This part of the booklet is also well illustrated and I have no doubt that students would experience little difficulty in identifying most common insects to order.

I have no criticism of note. However, I feel some things warrant consideration before printing a future edition. I found paragraph three on page 12 confusing; the text recommends (pp. 5, 12) that ethyl alcohol be used for wet preservation and while this is correct such material cannot be purchased by the general public—no alternative is suggested but students could use methylated spirits if necessary; and I wonder how many students would scan the Order illustrations searching for a picture of a cicada.

As an introductory text, especially for secondary school biology courses I cannot recommend this booklet too strongly. The Preface states that the primary aim for writing this booklet was to fulfil such a need and this it does admirably. It is very cheap, well written and well illustrated.

M. S. MOULD



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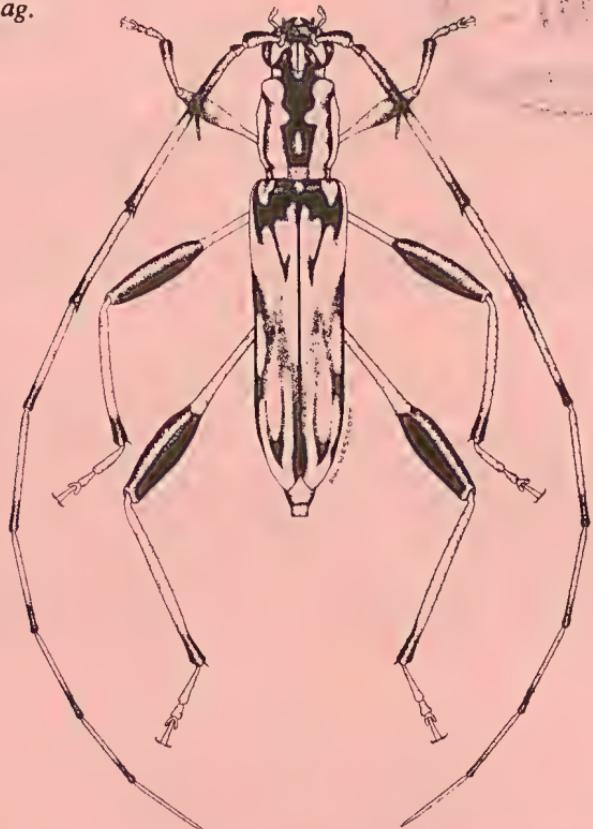
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**VOLUME 7, PART 3**

**NOVEMBER, 1980**

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## COVER

Illustrated by Alan E. Westcott.

Depicts the citrus longicorn, *Skeletodes tetrops* Newman, the larvae of which are commonly found in decaying citrus wood in eastern New South Wales. Eggs are laid in dead bark, usually after damage by other longicorn species, and the larvae make shallow tunnels packed with flour-like frass. The species is not considered to be economically significant.

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# Australian Entomological Magazine

Aust. ent. Mag.



Volume 7, Part 3

November, 1980

## NOTES ON SOME BUTTERFLIES FROM GLENBROOK, NEW SOUTH WALES

By T. J. Hawkeswood

Department of Botany, James Cook University, Townsville, Queensland 4811

### Abstract

Notes on four species of butterfly feeding on sap from *Eucalyptus gummifera* at Glenbrook, New South Wales, during February 1977, are provided. A tachinid fly parasite, *Exorista* sp.; from pupae of *Jalmenus evagoras evagoras* (Donovan) is recorded.

### Introduction

The township of Glenbrook is situated about 70 km by road west of Sydney at an altitude of 163 m. It receives an average annual rainfall of about 80 cm and temperatures range broadly from 1°C to 40°C.

Much of the natural bushland in the immediate vicinity of Glenbrook has made way for residential development but there are still areas where fruitful entomological collecting can be undertaken. The present vegetation is a dry sclerophyll forest composed of at least five species of *Eucalyptus* and three species of *Angophora*, with species of *Acacia* (Mimosaceae), *Hakea*, *Banksia* and *Persoonia* (Proteaceae) and *Bossiaea*, *Oxylobium* and *Phyllota* (Fabaceae) composing the shrub layers.

### Butterflies feeding on eucalypt sap

On 8th February 1977 two specimens of *Vanessa itea* (Fabricius), one male of *Polyura pyrrhus sempronius* (Fabricius), two females of *Heteronympha merope merope* (Fabricius) and one specimen of *Geitoneura klugii klugii* (Guérin-Méneville) were observed feeding simultaneously on the dark red-brown sap which had exuded from the trunk of a *Eucalyptus gummifera* (Gaertn.) Hochr. about 0.3 m from the ground. When disturbed, the specimens of *V. itea* closely circled the tree trunk several times reaching a height of some 2.5 m before rapidly flying to about 10 m and disappearing amongst the tree-top canopy. One *V. itea* returned to feed about four minutes later. The specimen of *P. p. sempronius*, when disturbed, rapidly flew at a height of 2-3 m over the shrub vegetation before disappearing and did not return. The specimens of *H. m. merope* and *G. k. klugii*, (two species which mainly frequent shady areas near the

ground) merely circled the tree several times when disturbed, before resting on the ground nearby for a period and afterwards returning to feed. When these two species were disturbed again they repeated this behaviour.

These observations are noteworthy since there appears to be little information at present available on adult behaviour exhibited by Australian butterflies. Three syndromes are noted here which may be related to escape behaviour: (a) rapid and direct flight by *Polyura*, (b) fast tree-trunk circling followed by rapid upward flight by *Vanessa* and (c) slow tree-trunk circling followed by resting in a camouflaged state in the shade of bushes by *Geitoneura* and *Heteronympha*. Although responses to natural predators have not been observed, it is likely that the behaviour exhibited by these butterflies could be effective against predation by animals such as birds. Further observations are necessary for a better understanding of this aspect of butterfly behaviour.

#### Parasite of *Jalmenus evagoras evagoras* (Donovan)

The parasitism of butterfly larvae by Diptera is well known and has been recorded many times, but Common and Waterhouse (1972, p. 32) note that remarkably little is known about the specific identity of the parasites involved.

In the Glenbrook area, larvae of *J. e. evagoras* feed on *Acacia falcata* (north of Glenbrook) and *A. decurrens* (in the Blue Mountains National Park, south of Glenbrook). On 17th February 1977, numerous larvae and pupae (attended by hundreds of black ants, presumably *Iridomyrmex*) were observed on a small bush of *A. falcata* (1.2 m high). Of thirteen pupae collected, three produced males and, ten days later, seven tachinid flies (*Exorista* sp.: Tachinidae: Goniinae: Exoristini) emerged from seven others. The three pupae remaining were parasitized but flies failed to emerge from them.

Unfortunately there is no modern treatment of the Australian Exoristini. Crosskey (1973) records the tachinid flies *Carcelia cosmophilae* (Curran) and *Exorista sorbillans* (Wiedemann) as parasites of *J. e. evagoras*, but Dr D. H. Colless (pers. comm.) believes that the name *sorbillans* was wrongly applied. Further research should reveal a great deal more information about tachinid parasites of Australian Lepidoptera.

#### Acknowledgements

I would like to thank Dr D. H. Colless, Division of Entomology, C.S.I.R.O., Canberra, for examining and identifying the tachinids, and Dr Colless and Mr M. S. Moulds for bringing to my attention the paper by Crosskey. I would also like to express my thanks to Mr J. D. O'Dea for critically examining the manuscript.

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## RECENT RECORDS OF *ACRODIPSAS ILLIDGEI* (WATERHOUSE AND LYELL) (LEPIDOPTERA: LYCAENIDAE) FROM THE BRISBANE AREA, QUEENSLAND

By Chris E. Hagan

Department of Entomology, University of Queensland  
St. Lucia, Queensland 4067

### Abstract

Recent captures of *Acrodipsas illidgei* (Waterhouse and Lyell) in mangroves at Redland Bay and Burleigh Heads are recorded. The finding of a pupa at Redland Bay confirms that the species is breeding in this area.

The distribution of *Acrodipsas illidgei* (Waterhouse and Lyell) is recorded from Brisbane to Burleigh Heads (Common and Waterhouse, 1972) and it is considered to be a very rare species. De Baar (1976) recorded one female taken in the Hay's Inlet area of Brisbane on the 16th September, 1973. More recently, the species has been rediscovered in a mangrove area at Burleigh Heads by Stephen Johnson in December 1978, and a number of adults have subsequently been taken at this locality (S. Johnson, pers. com.).

On 25th February, 1979, while examining mangroves at Redland Bay, approximately 35 km SE of Brisbane, an adult female *A. illidgei* was collected by the author. It was feeding at flowers of the grey mangrove, *Avicennia marina* (Forsk.) Vierh. (fam. Verbenaceae), along the seaward fringe. Later the same day a male was taken while settling at the top of another grey mangrove, approximately 5 m from the ground. *Hypochnysops epicurus* Miskin and *H. apelles* (Fabricius) were common in the area and were seen to be 'dog-fighting' near the tops of the mangroves. On 27th February, 1979, another male *A. illidgei* was taken in the same area, again near the top of a dead grey mangrove.

In September 1979, an *A. illidgei* pupa was located at Redland Bay in a hollow branch of a grey mangrove. This produced a female on 24th September (S. Johnson, pers. com.) and confirms that *A. illidgei* is breeding in the area.

### Acknowledgements

I would like to thank Mr S. J. Johnson for his information, Mr J. Davie, Department of Botany, University of Queensland, for identification of the mangrove and Miss J. Graff for her assistance.

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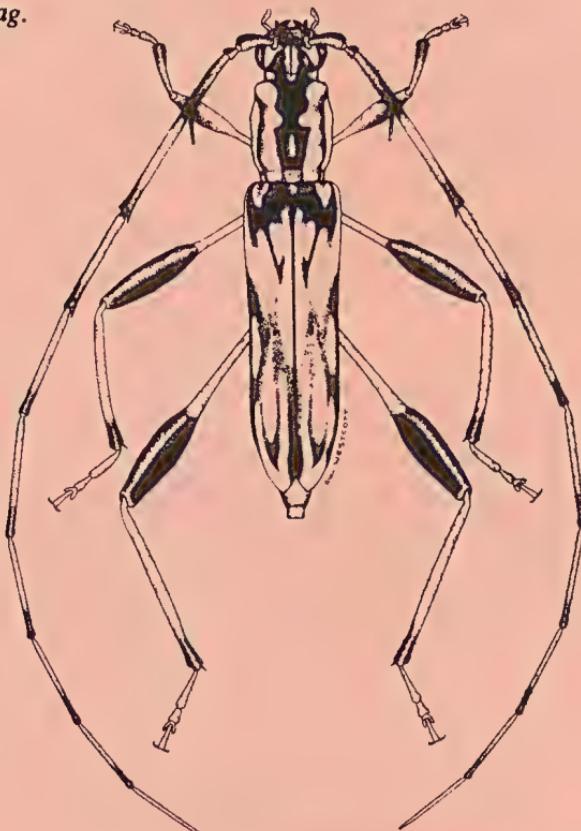
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**VOLUME 7, PART 4**

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Depicts the citrus longicorn, *Skeletodes tetrops* Newman, the larvae of which are commonly found in decaying citrus wood in eastern New South Wales. Eggs are laid in dead bark, usually after damage by other longicorn species, and the larvae make shallow tunnels packed with flour-like frass. The species is not considered to be economically significant.

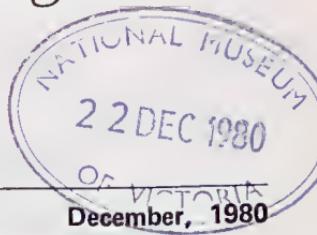
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# Australian Entomological Magazine

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Volume 7, Part 4



## A NEW SPECIES OF *MYIANOETUS* OUDEMANS (ACARINA: ANOETIDAE) FROM A CERATOPOGONID FLY IN AUSTRALASIA

By A. Fain and R. Domrow

Prince Leopold Institute of Tropical Medicine, Nationalestraat 155, B-2000 Antwerp, Belgium  
and

Queensland Institute of Medical Research, Bramston Tce, Herston, Australia 4006

### Abstract

*Myianoetus dycei* sp. n. is figured and described from hypopi phoretic on *Culicoides brevitarsis* Kieffer in northern Australia and Fiji. New subjective synonymy: *Anoestostoma* Womersley, 1941 = *Myianoetus* Oudemans, 1929.

### Introduction

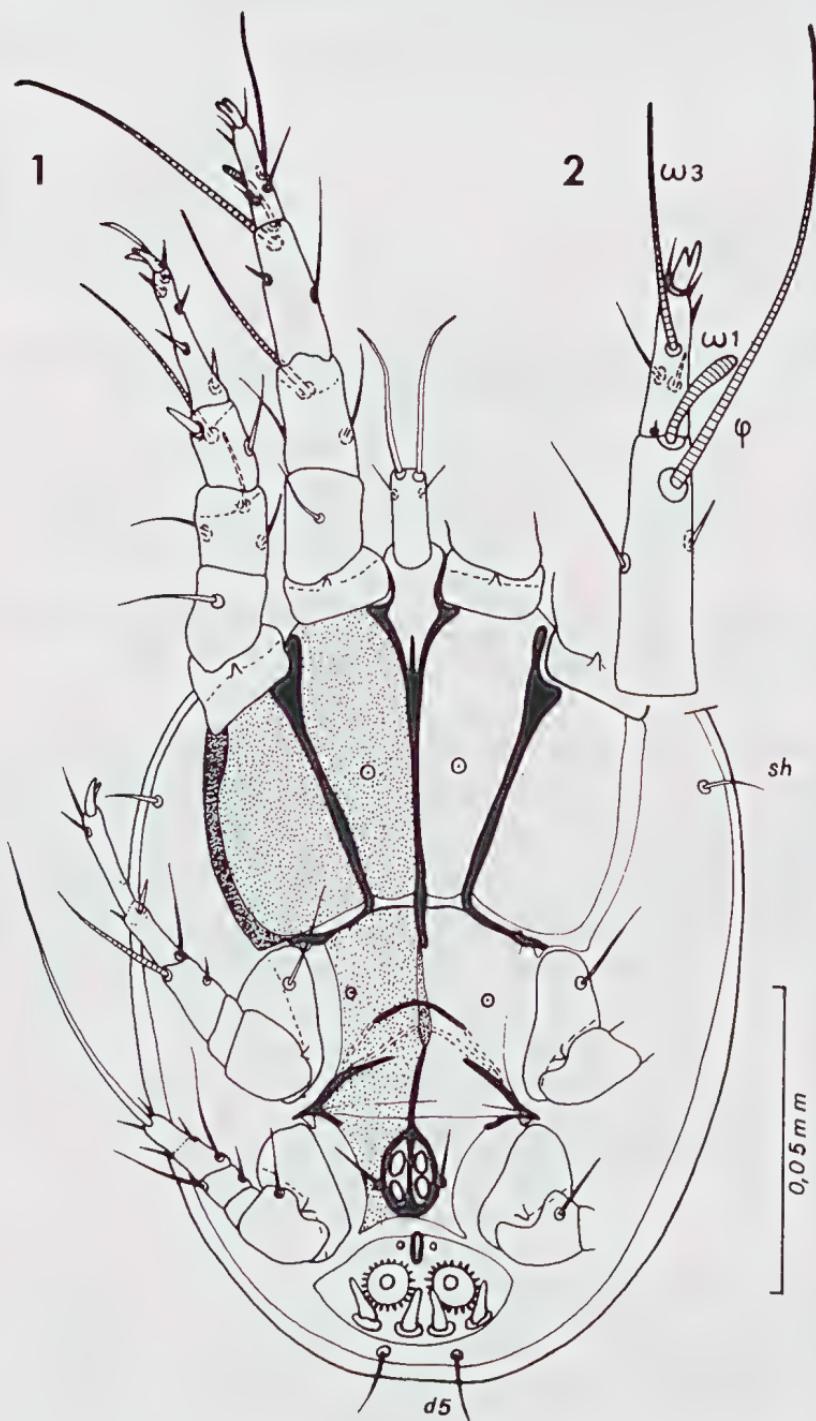
The introduced biting midge *Culicoides brevitarsis* Kieffer is well established as a vector of arboviruses in Australia (Doherty, 1972; Doherty *et al.*, 1972), and we now describe a hypopial mite commonly found phoretic on it. It belongs in *Myianoetus* Oudemans, a genus of *ca* 30 species mostly known only as hypopi phoretic on higher flies, especially Cyclorrhapha. However, the new record (the first from the lower ceratopogonids, Nematocera) is not surprising, since *C. brevitarsis* breeds in dung (Cannon and Reye, 1966), as do many Cyclorrhapha. It is undoubtedly in this biotope that the flies pick up their hypopi.

### Genus *Myianoetus* Oudemans

*Myianoetus* Oudemans, 1929, *Ent. Ber. Amst.* 7: 449. Type-species *Acarus muscarum* Linnaeus.  
*Anoestostoma* Womersley, 1941, *Rec. S. Aust. Mus.* 6: 485. Type-species *Anoestostoma oudemansi* Womersley (*sic*). *Syn. n.*

### *Myianoetus dycei* sp. n. (Figs 1-3)

*Material examined.* All hypopi, phoretic on *C. brevitarsis*, mostly on abdomen, as follows:— QUEENSLAND: Rockhampton, 20.ii.1968, A. L. Dyce (holotype and four paratypes); Parkhurst, 24.ii.1968, A.L.D. (nine paratypes); Kowanyama (formerly Mitchell River Mission), iv.1969, A.L.D. (five paratypes); Kowanyama, 1969, H.A. Standfast and E.T. Bulfin (five paratypes). NORTHERN TERRITORY:



Figs 1,2. *Myanoetus dycei*: (1) hypopus in ventral view; (2) tibia-tarsus I in dorsal view.

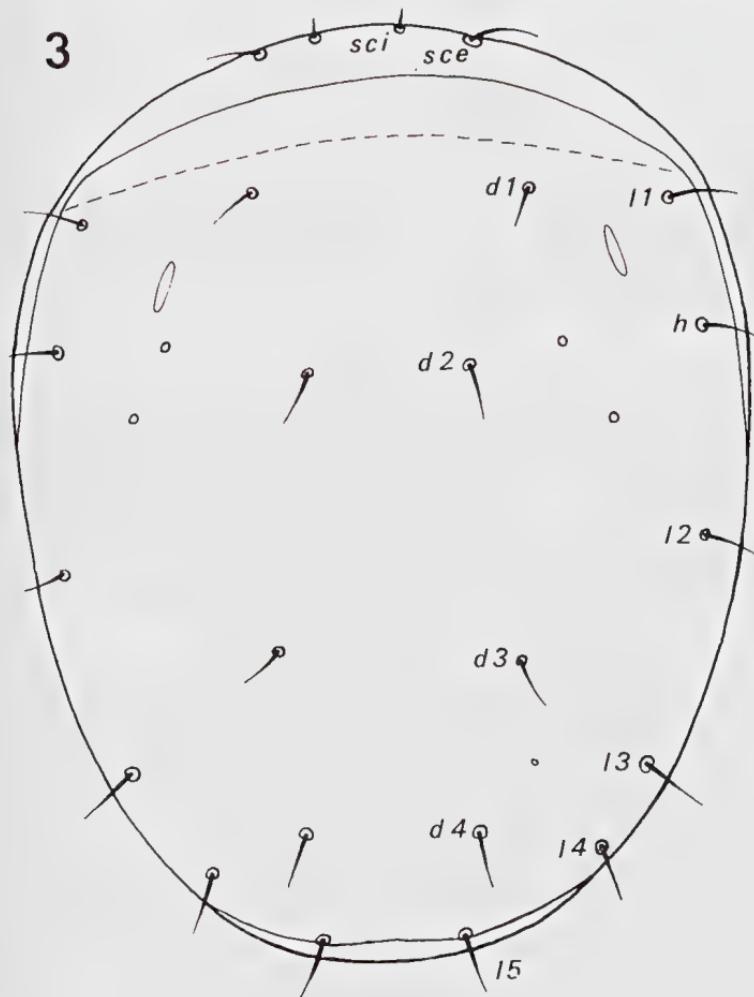


Fig. 3. *Myanoetus dycei*: idiosoma of hypopus in dorsal view.

Beatrice Hill, 25.i.1979, A.L.D. (11 paratypes); Berrimah Experiment Farm (10 miles = 16 km S of Darwin), 27-28.ii.1968, J. Haslam (five paratypes). FIJI: Viti Levu, 17.viii.1967, G. F. Bornemissa (four paratypes). Holotype in Australian National Insect Collection, CSIRO, Canberra; paratypes in authors' collections.

#### *Hypopus*

Holotype 141  $\mu\text{m}$  long, 108  $\mu\text{m}$  wide (four paratypes 135 x 110, 150 x 126, 156 x 130, 160 x 134). *Dorsum*: Propodonotum 15  $\mu\text{m}$  deep, with two pairs of setae ( $sci$  very short,  $sce$  longer). Hysteronotal setae short and thin. *Venter*: Sternum long, extended posteriorly into weakly sclerotised pregenital sclerite. Coxae II completely closed, connected to sternum by narrow transverse strip. Setae  $cx_1$

and  $cx_{III}$  represented only by their alveoli. Epimera IV not reaching midline. Suctorial plate rather small, with larger (posterior) pair of suckers 7.5-8  $\mu m$  in diameter, with denticulate rims; with two pairs of elongate conoids posteriorly set in curved line. *Palposoma* 15  $\mu m$  long, with pair of elongate solenidia (25  $\mu m$ ) apically. Legs: Tarsi I-IV 15, 24, 24, 14  $\mu m$  long, respectively. Tibia I 26-27  $\mu m$  long. Ratio of lengths of tarsus I: tibia I 1: 1.8. Tarsi I-III with bifid claw apically, IV with strong seta (45  $\mu m$ ). Solenidia on genua I-IV long. Solenidion  $\omega_1$  set dorsoapically on tibia I, just beyond solenidion  $\phi$ ; solenidion  $\omega_2$  probably represented by small seta set dorsobasally on tarsus I; solenidion  $\omega_3$  set middorsally on tarsus I.

### Notes

It may now be said that *Anoetostoma* Womersley, based on hypopi of *A. oudeansi* Womersley from the house fly, *Musca domestica* L. (Muscidae) in New South Wales, is a synonym of *Myianoetus* Oudemans\* since both show bifid claws on the legs (not mentioned in Womersley's text, but clear in his drawings), and a suctorial plate with one (posterior) pair of suckers enlarged and two pairs of conoids. The lattermost are not suckers as thought by Womersley, but soft conic projections probably serving as buffers to facilitate detachment from the host (Fain, 1973; 1974).

*M. dycei* is distinct from *M. oudeansi* in showing tarsus I shorter, rather than much longer, than tibia I (ratio of lengths 1 : 1.8 vs 1 : 0.5). In other species whose hypopi are known, tarsus I may range from longer to a little shorter than tibia I, but the ratio never exceeds 1 : 1.3 in the latter case. Other points seen only in *M. dycei* are the denticulate (posterior) suckers and the relatively elongate conoids on the suctorial plate.

The new species is named for Mr A. L. Dyce, McMaster Laboratory, CSIRO, Glebe, who collected many of the specimens and kindly read our draft manuscript.

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\* *Anoetostoma domrowi* Fain, 1968, based on hypopi from *Scoliophthalmus* sp. (Chloropidae) in New Guinea, is not a *Myianoetus* as here understood, and should be removed to another genus, possibly *Anoetus* Dujardin itself, to which it seems close.

## A LIST OF THE PAPILIONIDAE (LEPIDOPTERA) OF THE SOLOMON ISLANDS, WITH NOTES ON THEIR GEOGRAPHICAL DISTRIBUTION

By Tommaso Racheli

c/o Istituto di Zoologia, Università de L'Aquila, I-67100 L'Aquila, Italy

### Abstract

An account is given of the Papilionidae of the Solomon Islands, with taxonomic and distribution notes. The status of *O. allottei* Rothschild, *P. ponceleti* Le Moult, *P. erskinei* Mathew and *P. ptolychus* Godman and Salvin, is discussed. An attempt is made to show the relationships between this fauna and those of other parts of the Australian region.

### Introduction

Several papers on the papilionid butterflies of the Solomon Islands have appeared, but none contain a comprehensive discussion of all the species. It is hoped that the present list may, to some extent, rectify this situation.

The paper is based on extensive studies of the literature, on morphological studies of specimens in various collections, and on recent field data submitted by resident collectors. The Solomon islands are inhabited by 15 species of Papilionidae representing four genera. *Papilio oberon*, which inhabits S. Cruz island, has been included in the systematic section, but not in the data analysis.

### Geography

The Solomon group constitutes a long island arc in the South West Pacific consisting of one major and several minor clusters of islands covering an area of some 33900 km<sup>2</sup> and located east of New Guinea. The arc is oriented roughly NW-SE and in the NW, submarine mountains connect this group with the Bismarck Islands. Southwards, the Archipelago is continuous with the New Hebrides, which are separated from the Solomon group by the Santa Cruz Basin. This group of islands is probably not geologically linked to the Solomons but rather to the New Hebrides (Gressitt, 1961).

The Solomon Archipelago comprises two parallel rows of islands (Fig. 1), separated by "The Slot" channel. The main islands are Buka, Bougainville, Choiseul, Santa Isabel, Guadalcanal, Malaita, and Florida. The northernmost island is Buka and the southernmost San Cristobal. The rather isolated New Georgia Group with Vella la Vella, Gizo and Kolombangara, occupies a central position within the Archipelago.

The topography and vegetation are varied. Tropical rain forest covers large parts of the islands, except where cleared by man and on geologically younger ground, where a savannah-type vegetation often prevails, with lalang-grass (*Imperata*) etc. With the exception of the atoll-islands, all are more or less mountainous, with densely forested interiors. Mt. Lammas of Guadalcanal is nearly 2500 m high and several other islands of the group have mountains reaching about 1000 m. There are several active volcanoes, e.g. Balbi (3123 m) and Bagana (2251 m), both in Bougainville. Mountain slopes and hills are often covered extensively by dense rain forest, with various palms, hardwood trees, *Ficus* etc. The low-altitude vegetation consists mainly of ferns, banana trees and their like, with epiphytes and lianas. In coastal areas vast grounds

are cultivated and scattered secondary forests exist inland. Along tidal river courses, terminating in the ocean, swamplands and mangroves are often present. In Guadalcanal the grassy plains appear to be the result of relatively recent, but nevertheless total, clearing of the virgin forest. The climate is equatorial, with some seasonal variation in temperature, wind and precipitation. During the rainy season a monsoon-type wind prevails from April to November in large parts of the Solomons.

### Systematic section

The following abbreviations have been used below: FW, fore wing; HW, hind wing

#### *Ornithoptera victoriae* (Gray), 1856

This highly variable species has been discussed by Schmid (1970b, 1973b) who placed *resplendens* Ehrmann as a synonym of *regis* Rothschild, with which I fully concur. Numerous specimens of most of the described subspecies are difficult to assign to one or the other taxon, thus reflecting the great variability of the species. The populations from New Georgia Group, described as *rubianus* Rothschild, are characterised by a greater stability of the phenotype and it may be speculated that they have been isolated for longer time.

The following subspecies have been described:—

- O. victoriae victoriae* (Gray, 1856). Type loc.: not stated [Guadalcanal]
- O. victoriae reginae* (Salvin, 1888). Type loc.: Malaita: NW Bay
- O. victoriae regis* (Rothschild, 1895). Type loc.: Bougainville and Alu
- O. victoriae isabellae* (Rothschild and Jordan, 1901). Type loc.: Isabel
- O. victoriae epiphanes* Schmid, 1970. Type loc.: San Cristobal: Manowiriwiri
- O. victoriae rubianus* (Rothschild, 1904). Type loc.: Rendova

*Distribution*:— Bougainville; Alu; Shortland Is.; Rubiana; Kolombangara; New Georgia; Munda; Rendova; Ranonga; Guadalcanal: Poha, and Aola; Tulagi; Florida; Nggela; Malaita; Auki; Choiseul: Sasamuga and Kia, Nanango; St. Isabel: Mt. Marescot; S. Cristobal: Manowiriwiri, Kira Kira, Wainou, Star Harbour; Bauro.

#### *Ornithoptera allottei* (Rothschild), 1914

The status of this taxon has been discussed by McAlpine (1970), Schmid (1970b, 1973b), D'Abra (1975) and Haugum and Low (1978). Rousseau-Decelle (1939) was the first to suggest that *allottei* might be a hybrid of *O. victoriae* x *O. priamus urvillianus*, but Pere Allotte, the discoverer of the specimen, had earlier suggested this in a letter to Rothschild (Rothschild, 1914). Subsequent authors have treated *allottei* alternatively as a good species or as a hybrid in the absence of conclusive proof of one or the other. Schmid (1970a) found diagnostic characters to support the distinctiveness of *allottei* whilst McAlpine (l.c.) concluded (by what was claimed to be a lack of morphological features of its own) that *allottei* is a hybrid. Both Haugum and Low (l.c.) and Blandin (1973) are dubious about considering *allottei* a good species. In the light of recent findings of natural hybridization in other *Ornithoptera* and in *Ornithoptera* x *Troides* (Straatman, 1976; Sands and Sawyer, 1977), which is not as rare as was originally believed, new strength has been added to the hybrid origin theory for *allottei*, with which I agree. Moreover, *O. allottei* has only been recorded from the south of Bougainville and Malaita (Morgan, pers. comm.), where there are relatively high population densities of both *O. victoriae* and *O. priamus urvillianus* (Straatman, 1976 and pers. comm.). In these localities freely interspecific mating has sometimes been observed and the hatched larvae have been successfully reared through the initial instars, but unfortunately were eaten later by frogs (Straatman, pers. comm.).

*Distribution*:— Bougainville: Buin; South of Malaita.

#### *Ornithoptera priamus urvillianus* (Guérin-Méneville), 1838

A marked geographic variation is apparent in this widespread subspecies, which is distributed practically throughout the Solomon Islands. A subspecies *burkei* Clark, 1944,



Fig. 1. Map of the Solomon Archipelago.

was described from the southern Solomons but was placed as a synonym of *urvillianus* by Howarth (1977), whom I support. McAlpine (l.c.) and D'Abra (1975) consider this taxon a valid species different from *O. priamus* L.

*Distribution:*— Buka; Bougainville: Buin, Kunua; Treasury Is.; New Georgia; Gizo; Rendova; Bango Pingo; Isabel: Boala, Tatamba; Choiseul: Nanango; Malaita: Tanabu; Fauo; Tulagi; Florida; Guadalcanal: Honiara; Savo. It probably occurs on the numerous minor islets, but it has never been reported from Ugi and S. Cristobal.

### *Pachliopta polydorus* (Linnaeus), 1758

This species is the sole representative of the genus in the Solomons and was discussed in detail by Howarth and Racheli (1975).

There are three distinct subspecies:—

*P. polydorus polydaemon* (Mathew), 1887. Type loc.: Ugi Is.

*P. polydorus ulawaensis* (Joycey and Talbot), 1918. Type loc.: Ulawa Is.

*P. polydorus polypemon* (Mathew), 1887. Type loc.: Treasury Is.

*Distribution:*— Bougainville: Buin; Gauro; Alu; Treasury Is.; Shortland Is.; Vella la Vella; Gizo; Ranongga; Rendova; Choiseul; Isabel: Kia; Malaita; Florida; Guadalcanal: Honiara, Tete; Ulawa; Ugi; S. Cristobal.

### *Papilio bridgei* Mathew, 1886 (Figs 2-9)

This species shows considerable phenotypic variability along its range, however it is constant within each insular population. The phenotype of Malaita appears to be hitherto unrecorded and is interesting since it is intermediate between those of New Georgia and S. Cristobal. The ♂♂ specimens from Malaita show the post discal band of FWs rather poorly defined. It is complete on the upperside of FWs, with no black lines along the veins crossing the relatively large band of HWs. It seems probable that there is a formation of a clinal series in this species, with regard to this character. The ♀♀ are slightly larger than those of other populations (length of FW 85 mm). The discal patches of both FWs and HWs are more darkened, the marginal white spots enlarged, the submarginal spots large and filled with orange. Upon examination of the holotype ♂ in the British Museum collection, *Papilio erskinei* Mathew, 1886, was found to be conspecific with *P. bridgei*.

A further ♂ recently received from S. Cristobal, is similar to the holotype, except that it has traces of submarginal spots in S2 and S3 on the underside of HWs.

No attempt was made in the list by Munroe (1961) to give the status of *P. erskinei* and this taxon was presumably overlooked by D'Abrera (1971) who subsequently (1978) considered it as a local form of *P. woodfordi*.

As far as *tryoni* Mathew 1889 is concerned, I had the opportunity to examine a colour slide of the holotype ♂. The specimen, which is very battered, is said to come from Ugi Is., namely the locality where *P. erskinei* flies. It might be that different populations of *P. bridgei* occur in different parts of the island, even though this hypothesis is rather doubtful. The two other possibilities are either that *tryoni* is an aberration of *erskinei* or that the locality is wrong. This latter possibility is supported by the fact that the holotype of *tryoni* resembles all the other populations of *bridgei* within the Solomons, except that of S. Cristobal. In fact, the apical patch of both FWs is missing, a costal streak is present on the upper side of the HWs and the colouration of the submarginal spots on the underside of the HWs is light yellow-green. These characteristics are absent in *P. erskinei*. Moreover, Jordan (1909) described two females that he referred to as females of *P. tryoni*, but which are undoubtedly females of *P. erskinei*. Two females of this taxon, recently received from S. Cristobal, correspond to Jordan's diagnosis yet are females of *P. bridgei*, from which it may be concluded that *P. erskinei* is conspecific with *P. bridgei*.

Since we cannot completely depend upon the previously recorded localities, the type locality of *Papilio bridgei erskinei* Mathew 1886 Stat. nov., should be restricted to S. Cristobal.

Finally, I have some doubts about the status of *tryoni* until new material becomes available.

The geographical distribution of *P. bridgei* may be summarized as follows:—

*P. bridgei bridgei* Mathew, 1886. Type loc.: Treasury Is.

*P. bridgei prospero* Grose-Smith, 1889. Type loc.: Rubiana

*P. bridgei ortegae* Rothschild, 1904. Type loc.: Florida

*P. bridgei hecateus* Godman & Salvin, 1888. Type loc.: Guadalcanal

*P. bridgei erskinei* Mathew, 1886. Type loc.: Ugi Is.

*P. bridgei tryoni* Mathew, 1889. Type loc.: Ugi Is. ?

*Distribution:*— Buka; Bougainville; Shortland Is.; Alu; Fauro; Treasury Is.; Choiseul; Masamasa; Isabel; Tatamba, Sepi; Malaita; Auki; Rubiana; Gizo; New Georgia; Munda; Rendova; Vella la Vella; Florida; Gela; Guadalcanal; Koala Ridge, Honiara; Ugi; S. Cristobal.

### *Papilio oberon* Grose-Smith, 1897

This species shows a marked stability of the pattern in a long series examined. Jordan (1909) suggested that the affinities of *P. oberon* are with *Papilio aegeus* Donovan. This may be so, however it resembles morphologically the Australian subspecies of *P. aegeus* more than any forms which are geographically nearer to it.

*Distribution:*— S. Cruz: Tevai.

### *Papilio woodfordi* Godman and Salvin, 1888

This species is strikingly variable, but stable within each population. Having examined large series of specimens, I have come to the conclusion that the taxon known as *P. ptolemy* Godman and Salvin, 1888 is conspecific with this species.

Four geographical subspecies should therefore be considered:—

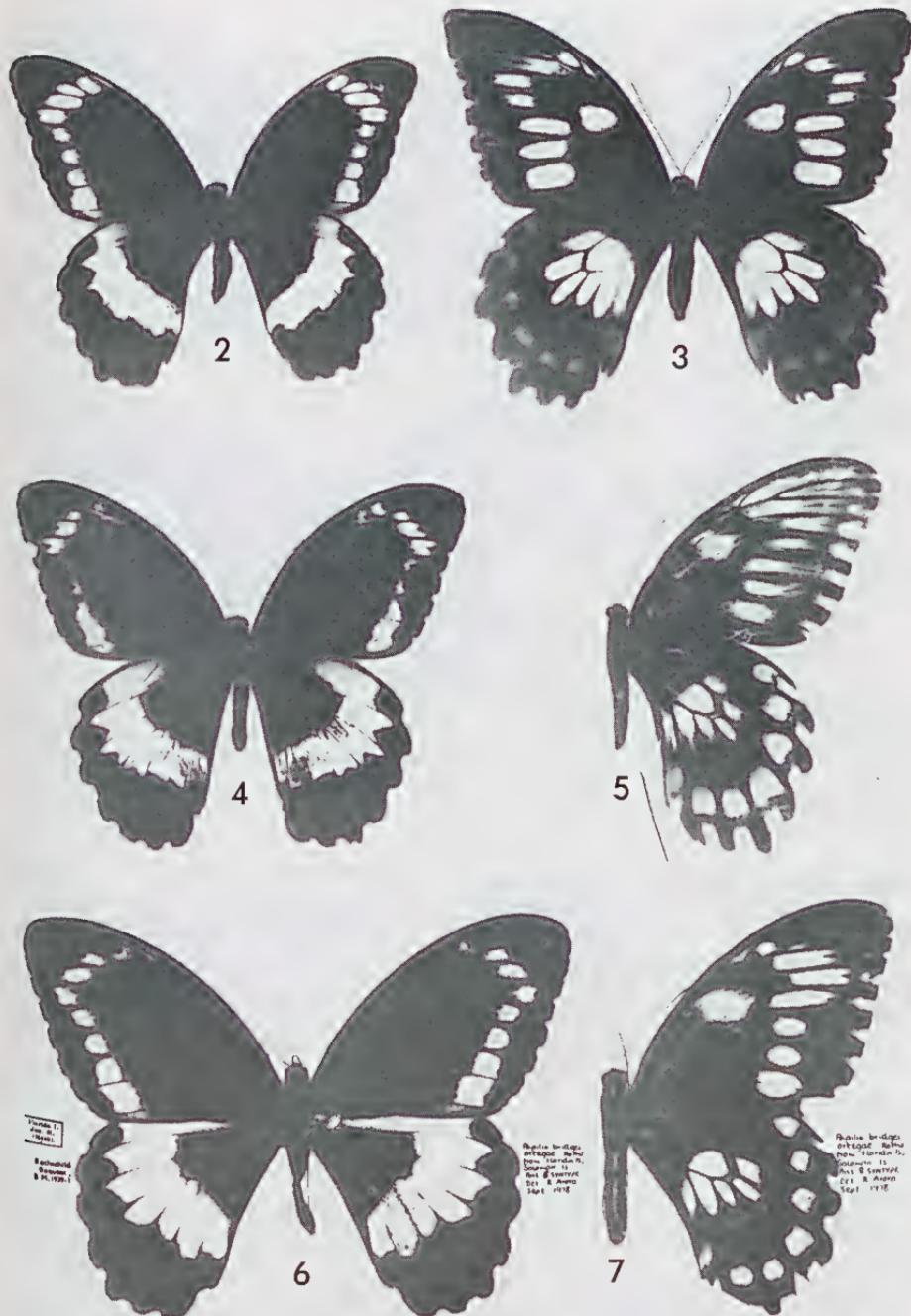
*P. woodfordi woodfordi* Godman and Salvin, 1888. Type loc.: Alu and Fauro

*P. woodfordi ariel* Grose-Smith, 1889. Type loc.: Isabel: Estrella Bay

*P. woodfordi laarchus* Godman and Salvin, 1888. Type loc.: Rubiana

*P. woodfordi ptolemy* Godman and Salvin. Type loc.: Guadalcanal: Aola. Stat. nov.

*Distribution:*— Buka; Bougainville; Buin; Alu; Fauro; Shortland Is.: Tiap; Rubiana; New Georgia; Gizo; Kolombangara; Isabel: Tatamba, Sepi, Holibara, Hageulu; Malaita; Choiseul; Guadalcanal: White River and Mt. Balbi; Florida.



Figs 2-7. (2-3) *P. bridgei erskinei*: (2) ♂ upperside, S. Cristobal, 28.viii.1974 (3) ♀ upperside, S. Cristobal, 28.viii.1974; (4-5) *P. bridgei* ssp.; (4) ♂ upperside, Malaita, Auki, 11.v.1973, (5) ♀ upperside, Malaita, 4.vii.1973; (6-7) *P. bridgei ortegae*: (5) ♂ upperside, Florida, 1.1901, Meek leg., syntype, Brit. Mus. (Nat. Hist.), (7) ♀ upperside, data as for ♂. Specimens in author's collection unless otherwise stated.

### *Papilio fuscus* Goeze, 1779 (Figs 10-11)

A widely distributed and highly variable species. The arrangement, traditionally considered for all populations of central and south Solomons referred to ssp. *xenophilus* Mathew 1886, by Rothschild (1895), Jordan (*I.c.*) and D'Abra (1971, 1978), appears to be erroneous and the name *xenophilus* should be restricted to the populations of Ugi and S. Cristobal. They may be distinguished from populations of other Solomons on account of the constant pure white bands of both wings and also their smaller size. As pointed out by Jordan (*I.c.*), *P. fuscus xenophilus* appears to be closely related to *Papilio canopus* Westwood, 1842; the relationships between these two taxa will be discussed below.

In my opinion only two subspecies should be considered in the Solomon Islands: *P. fuscus hasterti* Ribbe, 1907 (Type loc. Bougainville: Gieta or Kieta), distributed on the main chain except Ugi and S. Cristobal where *P. fuscus xenophilus* Mathew, 1886 (Type loc. Ugi) occurs. The name *epibomius* Fruhstorfer, 1907, used to designate the population of Florida, should be regarded as a synonym of *hasterti* Ribbe.

*Distribution:*— Buka; Bougainville: Kieta; Alu; Shortland Is.; Isabel; New Georgia; Gizo; Rendova; Malaita: Auki; Florida; Russel Is.: Pavuvu; Guadalcanal; Ugi; S. Cristobal.

### *Papilio ponceleti* Le Moult, 1933

This supposed species has been described by Le Moult (1933), on the basis of one male and one female from Bougainville, Kieta. Since then no other author has recorded it. Unfortunately, I have been unable to examine these specimens which were sold in 1966 at Rousseau-Decelle's auction in Paris.

Le Moult (*I.c.*), in his description, noted the great similarity of *ponceleti* with *woodfordi* and *fuscus*, it being intermediate in many characters between these two species.

Straatman (1962) gives illustrations of an experimental hybrid resulting from *P. aegeus aegeus* Donovan x *P. fuscus capaneus* Westwood. Even though there are no pattern relationships between this hybrid and *ponceleti*, the tail reduced to a stump in this hybrid is not unlike that of *ponceleti*. Many other records of crosses between tailed and untailed papilios show that the tails of resulting off-spring are reduced in length. The status of *ponceleti* is questionable and its hybrid origin, *P. fuscus* x *P. woodfordi* seems a likely explanation.

### *Papilio phestus* Guérin-Méneville, 1830

Apparently never recorded from Malaita, Guadalcanal and S. Cristobal. The most southern locality known to the author is Russel Is. (1 ♂, in Reijksmuseum van Natuurlijke Historie, Leiden). It is possible that the various populations recorded refer to only one subspecies, namely *minusculus* Ribbe, 1898 (Type loc. Shortland Is.), even though some populations may be distinguishable. The white discal spots on the underside of HWs are mostly reduced in the northern populations while the same spots are larger and similar to those of nominotypical *phestus* in specimens from central and southern Solomons.

*Distribution:*— Bougainville: Buin; Alu; Treasury Is.; Choiseul; Isabel: Tatamba; Rubiana; New Georgia; Gizo; Vella la Vella; Kolombangara; Russel Is.

### *Papilio ulysses* Linnaeus, 1758

The subspecies were discussed by Jordan (*I.c.*) who applied various names to the female forms occurring in the Solomons. There is one geographical subspecies on the main Solomon chain, another in the New Georgia Group and a third in the Shortlands and on Bougainville. Subspecies *orsippus* Godman and Salvin, 1888 is distributed on Guadalcanal (Type loc.), Choiseul, Isabel and Florida, and is dimorphic in the female. Subspecies *georgius* Rothschild, 1908 occurs on Gizo (type loc.), Kolombangara, Ranongga and Vella la Vella of the New Georgia Group, and subspecies *nigerrimus* Ribbe, 1898 on Bougainville and the Shortland Islands.

*Distribution:*— Bougainville: Buin; Shortland Is.; Alu; Isabel: Sepi; Choiseul; Vella la Vella; Gizo; Kolombangara; Ranongga; Guadalcanal: Honiara, Koala Ridge; New Georgia; Florida.



Figs 8-11. (8-9) *P. bridgei tryoni*: (8) ♂ upperside, Ugi Is., "Type", Brit. Mus. (Nat. Hist.), (9) ♂ underside, same specimen; (10-11) *P. fuscus xenophilus*: (10) ♂ upperside, S. Cristobal, ii.iii.1974, (11) ♀ upperside, S. Cristobal, 2.iii.1974. Specimens in author's collection unless otherwise stated.

#### *Papilio toborei* Ribbe, 1907 (Figs 12-13)

The biology and ecology of this species was described by Straatman (1975), the taxonomy by Racheli (1979). The species seems to be rather localised and distributed only in Bougainville, Isabel and Malaita.

Two subspecies are recognised, namely:—

*P. toborei toborei* Ribbe, 1907. (Type loc. Bougainville: Gieta)

*P. toborei straatmani* Racheli, 1979. (Type loc. South Isabel: Holibara)

*Distribution*:— Bougainville: Gieta, Borabere, Tiop; Isabel: Holibara; Malaita.

#### *Graphium codrus* (Cramer), 1779

Widespread but apparently uncommon in the Solomons. The taxonomy and distribution were discussed by Yoshida (1972) and Racheli (1979).

Four subspecies can be distinguished:—

*G. codrus gabriellae* Racheli, 1979 (= *solon* Godman and Salvin, 1888 nec *solon* Fabricius, 1793). Type loc.: Guadalcanal: Aola.

*G. codrus pisidice* (Godman and Salvin), 1888. Type loc.: Malaita: North-west Bay.

*G. codrus tenebrionis* (Rothschild), 1895. Type loc.: New Georgia.

*G. codrus christobalus* (Jordan), 1909. Type loc.: S. Cristobal.

*Distribution*:— Bougainville; Alu; Shortland Is.; Choiseul; Malaita: Auki; Rendova; Ranongga; Vella la Vella; Gizo; New Georgia; Florida; Guadalcanal; S. Cristobal.

#### *Graphium sarpedon* (Linnaeus), 1758

Not recorded from Malaita and S. Cristobal but otherwise widespread in the Solomons in two, or possibly three, subspecies:—

*G. sarpedon isander* (Godman and Salvin), 1888. Type loc.: Guadalcanal: Aola  
*G. sarpedon impar* (Rothschild), 1895. Type loc.: New Georgia

And possibly:— *G. sarpedon shortlandica* (Ribbe), 1900. Type loc.: Shortlands, but <sup>sin</sup>  
 such a meagre quantity of specimens is known, it is impossible to decide whether or not  
 it represents a valid subspecies

*Distribution*:— Bougainville; Shortlands; Fauro; Alu; Isabel; Choiseul; Kolombangara; Gizo;  
 Vella la Vella; Rendova; Rubiana; New Georgia; Guadalcanal; Florida.

### *Graphium mendana* (Godman and Salvin), 1888 (Figs 14-16)

This species seems to be rather rare and is not represented in many collections.  
 It has been bred by Straatman (pers. comm.) on Malaita, but no description of the  
 preimaginal stages has been published.

There are four subspecies in the Solomons:—

*G. mendana acous* (Ribbe), 1898. Type loc.: Bougainville: Aco

*G. mendana neyra* (Rothschild), 1895. Type loc.: New Georgia

*G. mendana mendana* (Godman and Salvin), 1888. Type loc.: Guadalcanal: Aola

*G. mendana aureofasciatum* Racheli, 1979. Type loc.: NW Malaita: Dala

*Distribution*:— Bougainville: Aco; Isabel; Malaita: Dala; Rubiana; Rendova; Vella la Vella;  
 Guadalcanal: Aola.

### *Graphium agamemnon* (Linnaeus), 1758 (Figs 17-18)

A widely distributed species having phenotypically similar populations throughout the Solomons. The only exception being found on Ugi and S. Cristobal inhabited by subspecies *ugiensis* (Jordan, 1909). This subspecies differs notably from the more widespread subspecies *salomonis* (Rothschild, 1895). Subspecies *ugiensis* was previously considered endemic to Ugi Is., however the ♀ holotype from Ugi matches well with specimens from S. Cristobal I examined and I have no doubt that these specimens belong to the same subspecies.

I am also of the opinion that the presence or absence of red spots between the median veins of the HWs, as described by Jordan (1909), is an unreliable character for distinguishing between subspecies of *G. agamemnon*; whereas this character has been used to distinguish subspecies *ugiensis*, where the red spots are absent. An identical state of affairs exists in specimens from other Solomons populations. In 100 specimens examined from localities throughout the species range, the red spots were found to vary in number, usually from three to seven. *G. agamemnon ugiensis* may be safely identified by the somewhat produced or falcate shape of the FWs, its smaller size and the more yellowish colour of the spots on the upper surface.

*Distribution*:— Bougainville; Shortland Is.; Alu; Choiseul; Isabel; Tatamba; Malaita; Kolombangara; Gizo; Rendova; Vella la Vella; Florida; Gela; Guadalcanal; Honiara, Koala Ridge; Ugi; S. Cristobal.

### *Graphium meeki* (Rothschild), 1901

This species is fairly rare and is confined inland, where it occurs in mountainous areas (Straatman, pers. comm.). It may be locally not uncommon in suitable habitats. I wonder if D'Abrera (1971) was misled by the apparent lack of recent specimens in collections when he stated that the species is "probably extinct". The same author (1971) reports on another specimen to be found in the Australian Museum, Sydney. This specimen is presumably the same figured by Musgrave (1946) and seems not to have a different pattern from that of the holotype.

The species has been found in Bougainville (Rousseau-Decelle, 1946; Musgrave, 1946; D'Abrera, 1978); Isabel (type loc.) and Choiseul (Morgan, pers. comm.).

*Distribution*:— Bougainville: Porubi and Piva Riva, Empress Augusta Bay; Choiseul; Isabel: Hageulu 650 m.

### *Graphium hicetaon* (Mathew), 1886

Another species endemic to the Solomon Islands. It is widespread but has not previously been recorded from Isabel, Malaita and S. Cristobal. The geographic variation



12



13



14



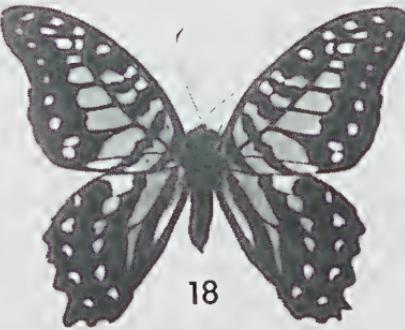
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16



17



18

Figs 12-18. (12-13) *P. toboroi straatmani*: (12) ♂ upperside, S. Isabel, Holibara, 750m, 22.viii. 1964, Straatman leg., holotype in coll. Nieuwenhuis (Rijksmuseum van Natuurlijke Historie, Leiden); (13) ♂ underside, same specimen; (14) *G. mendana mendana*, ♂ upperside, Isabel, x.1972; (15) *G. mendana neyra*, ♀ upperside, Vella la Vella, 4.x.1973; (16) *G. mendana aureofasciatum*, ♂ upperside, NW Malaita, Dala, ex pupa, 1.vii.1964, Straatman leg; holotype in coll. Nieuwenhuis (Rijksmuseum van Natuurlijke Historie, Leiden); (17) *G. agamemnon salomonis*, ♂ upperside, Guadalcanal, v.1968; (18) *G. agamemnon ugiensis*, ♀ upperside, S. Cristobal, ix. 1974. Specimens in author's collection unless otherwise stated.

entirely insignificant, in spite of the isolation within the islands. Therefore, it might be assumed that there is a high degree of gene flow.

**Distribution:**— Bougainville: Kahili, Kunua, Kieta; Shortland Is.; Choiseul; Isabel; Malaita; Rendova; Vella la Vella; Gizo; Florida; Guadalcanal, Ugi; S. Cristobal: Kira Kira.

### Discussion

#### *Distribution of Papilionidae in the Solomon Archipelago*

Fifteen species of Papilionidae (or 16 if we consider *P. oberon* which inhabits Santa Cruz Island as belonging to this fauna) occur in the Solomons (Table 1) (*O. allottei* and *P. ponceleti* have been excluded because of their doubtful specific status—see text). Seven of these are endemic of which *O. victoriae*, *P. bridgei*, *P. woodfordi* and *G. hicetaon* are common and widespread in all the islands. Only *P. woodfordi* appears not to have reached San Cristobal. *P. toboroi* and *G. meeki* are apparently uncommon and confined to the eastern Solomons; *P. toboroi* is also to be found on Choiseul. *G. mendana* seems to have spread to most of the islands except San Cristobal, and to have developed in Malaita a subspecies with a striking colour pattern nearing that of *G. codrus*. Bougainville is the only island of the Solomons to have all the papilionid species known from the Solomons while San Cristobal has the lowest number (46.6%) (Table 1).

TABLE 1  
Number of species of Papilionidae occurring on each  
of the major islands of the Solomon Archipelago

Island	No. of spp	% of Archipelago total
Bougainville	15	100
Choiseul	13	86.6
Vella la Vella	9	60
New Georgia	13	86.6
Santa Isabel	14	93.3
Florida and Tulagi	11	73.3
Guadalcanal	12	80
Malaita	11	73.3
San Cristobal	7	46.6
Bellona	0	0
Rennel	0	0

It is interesting to note that there is a decrease in the number of papilionid species within the Solomon Archipelago between the islands from north to south and from east to west (Table 2).

Tables 3 and 4 show the ratios of papilionid species between the Solomons and the south-western Pacific/Australian region. It is worthwhile noting the high proportion of species endemic to the Solomons (Table 4), suggesting that these are relatively long established in these islands.

#### *Comparison of distribution patterns*

The Papilionidae of New Ireland and New Britain are identical both in number of genera and species of which 13% are endemic and 40% of Papuan origin. Seven species are shared with the Solomon Islands.

New Guinea, like the Solomons, has a high percentage of endemic species (40%), practically all confined to the genus *Ornithoptera*.

TABLE 2  
Distribution of Papilionidae occurring in the Solomon Islands

Species	Bougainville†	Choiseul†	Santa Isabel†	New Georgia	Guadalcanal	Malaita†	San Cristobal	Santa Cruz
<i>O. victoriae</i>	*	*	*	*	*	*	*	*
<i>O. allotlei</i>	*						*	
<i>O. urvillianus</i>	*	*	*	*	*	*	*	
<i>P. polydorus</i>	*	*	*	*	*	*	*	
<i>P. bridgei</i>	*	*	*	*	*	*	*	
<i>P. oberon</i>								*
<i>P. woodfordi</i>	*	*	*	*	*	*		
<i>P. fuscus</i>	*	*	*	*	*	*		
<i>P. phestus</i>	*	*	*	*				
<i>P. ulysses</i>	*	*	*	*	*			
<i>P. toborei</i>	*		*				*	
<i>G. codrus</i>	*	*		*	*	*		
<i>G. sarpedon</i>	*	*	*	*	*			
<i>G. mendana</i>	*		*	*	*		*	
<i>G. agamemnon</i>	*	*	*	*	*	*		
<i>G. meeki</i>	*	*	*					
<i>G. hicetaon</i>	*	*	*	*	*	*		

† Islands on the eastern side of the Solomon Archipelago.

The fauna of the Admiralty Islands is not as rich as that of other nearby archipelagoes; 50% of the species are west New Guinean and only one is endemic, namely *Papilio weymeri* Oberthür which is related to *P. bridgei* of the Solomon Islands. Seven of the eight species known from the Admiralty Islands are shared with New Britain, New Ireland and the Solomons; five with Australia.

Australia has a rather small number of Papilionidae, three are endemic, namely *Protographium leosthenes* (Doubleday), *Graphium macleayanum* (Leach) and *Papilio anactus* Macleay, seven are Papuan or West Papuan and six Oriental.

On the Oceanic Islands, Santa Cruz, New Caledonia, New Hebrides, Fiji and Samoa, there are few Papilionidae; all but one are endemic at the species level, the exception being *P. canopus hypsicles* Hewitson, confined to the New Hebrides.

The close morphological and pattern relationships between the taxa inhabiting San Cristobal and NW Australia suggests a relationship between *hypscicles* and *fuscus*. Many authors are of the opinion that *P. canopus* from NW Australia is nothing other than a subspecies of *P. fuscus*. Whether *P. fuscus* and *P. canopus*, being allopatric, are two biological species is hard to say, nevertheless there is geographic evidence that *P. fuscus* spreads westward to the Oriental region as far as the Andaman Islands, and eastward to New Guinea, northern and eastern Australia and through the Solomons to the New Hebrides. *P. fuscus* is also reported from the Torres Islands, located between Santa Cruz and the New Hebrides, as ssp. *nomus* Gabriel 1936. The *canopus* complex, on the other hand, is restricted and split into various different populations in the Lesser Sunda Islands where it has developed tailed, tailless and colour forms probably of mimetic value.

TABLE 3. Summary of the distributions of Papilionidae in the Australian and south-western Pacific regions.

Species	NG	AI	NB	NI	SOL	SC	Region							
							NH	F	S	NCL	AUS	LH	N	
<i>C. cressida</i>	*												*	P
<i>P. polydorus</i>	*	*	*	*	*	*							*	P
<i>T. oblongomaculatus</i>	*													P
<i>O. goliath</i>	*													E
<i>O. chimaera</i>	*													E
<i>O. tithonus</i>	*													E
<i>O. rothschildi</i>	*													E
<i>O. paradisea</i>	*													E
<i>O. meridionalis</i>	*													E
<i>O. priamus</i>	*	*	*	*	*	*							*	P
<i>O. alexandrae</i>	*													P
<i>O. victoriae</i>							*							E
<i>P. ulysses</i>	*	*	*	*	*	*							*	P
<i>P. montrouzieri</i>												*		P
<i>P. lorquinianus</i>	*													P
<i>P. deiphobus</i>	*													P
<i>P. ambrax</i>	*											*		P
<i>P. phestus</i>		*	*	*	*	*								BS
<i>P. albinus</i>	*													O
<i>P. fuscus</i>	*		*	*	*	*		can					*	O
<i>P. demoleus</i>	*												*	O
<i>P. euchenor</i>	*		*	*										P
<i>P. godeffroyi</i>												*		E
<i>P. schmeltzi</i>												*		E
<i>P. amyntor</i>												*		E
<i>P. bridgei</i>							*							E
<i>P. woodfordi</i>							*							E
<i>P. oberon</i>							*							E
<i>P. weymeri</i>		*												E
<i>P. aegeus</i>	*		*	*									*	E
<i>P. laglaizei</i>	*													E
<i>P. toborigi</i>							*							E
<i>P. moerneri</i>		*	*											E
<i>P. anactus</i>													*	E
<i>G. thule</i>	*													O
<i>G. aristaeus</i>	*		*	*									*	O
<i>G. wallacei</i>	*													O
<i>G. browni</i>		*	*											O
<i>G. hicetaon</i>							*							E
<i>G. agamemnon</i>	*	*	*	*	*	*							*	O
<i>G. meeki</i>							*							O
<i>G. macfarlanei</i>	*	*	*	*	*								*	P
<i>G. euryptylus</i>	*		*	*	*								*	O
<i>G. gelon</i>														E
<i>G. sarpedon</i>	*		*	*	*	*						*		O
<i>G. mendana</i>								*						E
<i>G. codrus</i>	*	*	*	*	*	*								C
<i>G. weiskei</i>	*													E
<i>G. macleayanus</i>	*											*	*	E
<i>P. leosthenes</i>	*											*	*	E

Abbreviations: NG—New Guinea  
 AI—Admiralty Islands  
 NB—New Britain  
 NI—New Ireland  
 SOL—Solomon Islands  
 SC—Santa Cruz Islands  
 NH—New Hebrides  
 F—Fiji  
 S—Samoa  
 NCL—New Caledonia & Loyalties  
 AUS—Australia  
 LH—Lord Howe Is.  
 N—Norfolk Is.  
 E—Endemic  
 P—Papuan  
 O—Oriental  
 BS—Bismarck to Solomons  
 CS—Celebes to Solomons  
 can—*Papilio canopus*

TABLE 4  
Total numbers of species and percentages of Papilionidae occurring in the  
Australian/south-western Pacific region showing faunal relationships

	New Guinea		Admiralty Islands		New Britain		New Ireland		Solomons		Australia		Entire Region	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Endemic	12	40	1	12.5	2	13.4	2	13.4	7	46.6	3	18.75	31	62
Papuan	11	36.7	4	50	6	40	6	40	3	20.1	7	43.75	11	22
Oriental	6	20	1	12.5	5	33.4	5	33.4	3	20.1	6	37.5	6	12
Bismarck to Solomons	0	0	1	12.5	1	6.6	1	6.6	1	6.6	0	0	1	2
Celebes to Solomons	1	3.3	1	12.5	1	6.6	1	6.6	1	6.6	0	0	1	2

Table 3 shows that only six species of Papilionidae are shared with Australia, New Guinea, the Bismarcks and the Solomons. They are *O. priamus* L., *P. polydorus* L., *P. ulysses* L., *P. ambrax/phestus*, *P. fuscus* Goeze and *G. agamemnon* L. The first four are typically Papuan, while the remaining two are Oriental and are faunal elements derived presumably from west of the Wallace line.

As suggested by Zeuner (1943), *O. priamus* has had successive waves of dispersal from the central Moluccas eastwards. Holloway (1973) is not in agreement with Zeuner regarding the origin and dispersal of the genus *Troides*. In any case, if *Troides* had a centre of dispersal in mainland Asia, this is not in contrast with the distribution of *Ornithoptera priamus*, *Pachliopta polydorus*, *Papilio ulysses* and *Papilio ambrax/phestus*. While it is difficult to demonstrate the exact centre of origin of *Ornithoptera*, which probably originated within Wallacea according to Zeuner (l.c.), *Pachliopta* and *Papilio* certainly spread from India and Asia to the Papuan region. It might be hypothesized that *P. ulysses* originated from a common ancestor of the *peranthus/ulysses* group which gave origin to *P. lorquinianus* C. & R. Felder and *P. ulysses* within Wallacea. The former remained restricted to the Moluccas and West Irian, while the latter spread eastwards. The *ambrax/phestus* complex is structurally similar to *P. polytes* L., and has probably recently separated into species. *P. polytes* is polymorphic in its females and linked to Batesian mimicry, while *P. ambrax* and *phestus* females are monomorphic, nevertheless dissimilar from males and related to a Batesian-Mullerian mimicry ring. It has been demonstrated that *P. ambrax* Boisd. and *P. aegeus* Don. are both synchronic and sympatric in some parts of their range, while there is no evidence that the ecology of the supposed models, i.e. *Cressida cressida* F. males and *P. polydorus* is the same. In the light of recent investigations on *P. memnon* L. carried out in Sumatra (Küppers, 1977) it is probable that Batesian mimicry, at least in Papilionidae, is not as common as might be expected.

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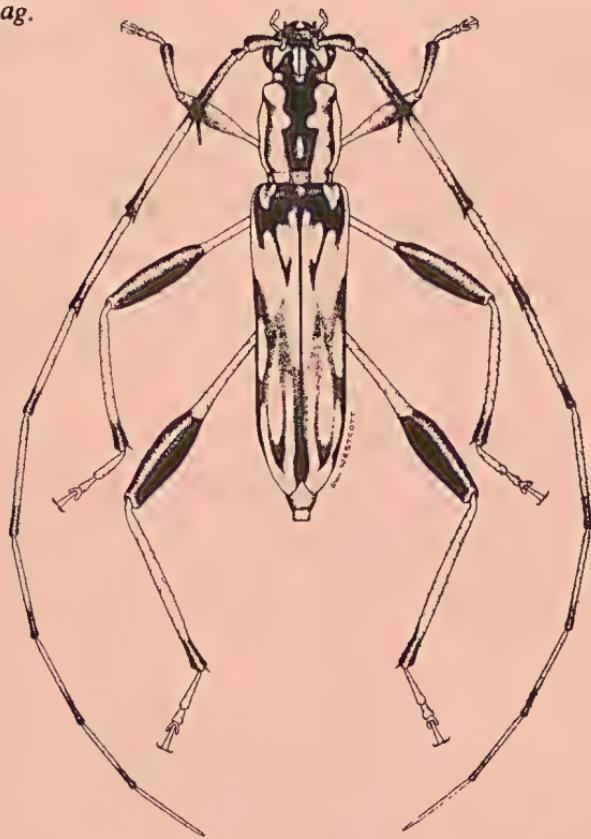
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## COVER

Illustrated by Alan E. Westcott.

Depicts the citrus longicorn, *Skeletodes tetrops* Newman, the larvae of which are commonly found in decaying citrus wood in eastern New South Wales. Eggs are laid in dead bark, usually after damage by other longicorns, and the larvae make shallow tunnels packed with flour-like frass. The species is not considered to be economically significant.

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# Australian Entomological Magazine

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## THE IMMATURE STAGES OF *ALOPHORA LEPIDOFERA* (MALLOCH) (DIPTERA: TACHINIDAE), A NATIVE PARASITE OF *LYGAEIDAE* (HEMIPTERA) IN AUSTRALIA

By B. J. Loudon and F. I. Attia

Biological and Chemical Research Institute, New South Wales Department  
of Agriculture, P.M.B. 10, Rydalmer, N.S.W. 2116

### Abstract

The immature stages of *Alophora (Mormonomyia) lepidofera* (Malloch) are described and figured for the first time. The caudal spiracles of the third instar larva have structures not previously recorded on those of other tachinids. The life cycle of this parasite is described in part and discussed along with its significance as a lygaeid parasite in Australia.

### Introduction

A tachinid fly identified as *Alophora (Mormonomyia) lepidofera* has been recorded as an endoparasite of the Lygaeidae *Nysius vinitor* Bergroth, *Nysius clevelandensis* Evans (Attia 1973), and has since been reared from another lygaeid, *Oxycarenus luctuosus* Montrouzier and Signoret. The specimens key to *A. lepidofera* in Malloch's (1929) key, match Malloch's description and illustrations (1930) and were compared with other specimens of *A. lepidofera* in the British Museum. However, the species name must be regarded as provisional in the absence of a revision of this species group and comparison with type material (Crosskey pers. comm. 1973). This fly has so far only been reported from New South Wales and its full distribution is not yet known.

Crosskey (1973) treats the cosmopolitan *Hyalomya* group as a subgenus of *Alophora* and places some Australian species of *Alophora* within it. In this sense, the genus *Alophora* is large and well represented world-wide with some recorded as parasites of Lygaeidae or other small Heteroptera (Thompson 1951, Eyles 1963, Crosskey 1973 and Arnaud 1978). Fourteen species of *Alophora* recorded from Australia are listed by Crosskey. Very few of these have hosts recorded for them and there are, as yet, no other descriptions of immature stages. *Alophora auriventris* Curran is recorded by Crosskey (*loc. cit.*) as a parasite of the pyrrhocorid *Dysdercus sidae* Montrouzier. Malipatil (1979) records *Alophora nigrihirta* (Malloch) parasitizing the lygaeid *Paraecucometus woodwardi* Malipatil. He also notes for other lygaeids, a similar larva from

*Horridipamera robusta* Malipatil, an *Alophora* sp. reared from *Arocatus rusticus* (Stal) as well as *Alophora ?lepidofera* from *Nysius vinitor* in Queensland.

*Nysius* species are widely distributed in all States of Australia (Woodward 1964) and frequently cause serious damage to summer crops (see Attia 1974). Evans (1936) mentions that in all *Nysius* pest species, outbreaks appear to be associated with prolonged dry summers but that in Australia dry summers are not always accompanied by outbreaks of *Nysius*. Thus, he concluded that other factors, partly biological, must be concerned in population fluctuations. Parasitism of *Nysius* spp. by *A. lepidofera* in New South Wales was recorded at a peak of 62% (Attia 1973) and could therefore be a mitigating influence on *Nysius* populations in some seasons. This paper presents known information on *A. lepidofera* and gives descriptions of the immature stages to assist further investigations into its potential in the biological control of *Nysius* species in Australia.

#### *Alophora lepidofera* (Malloch)

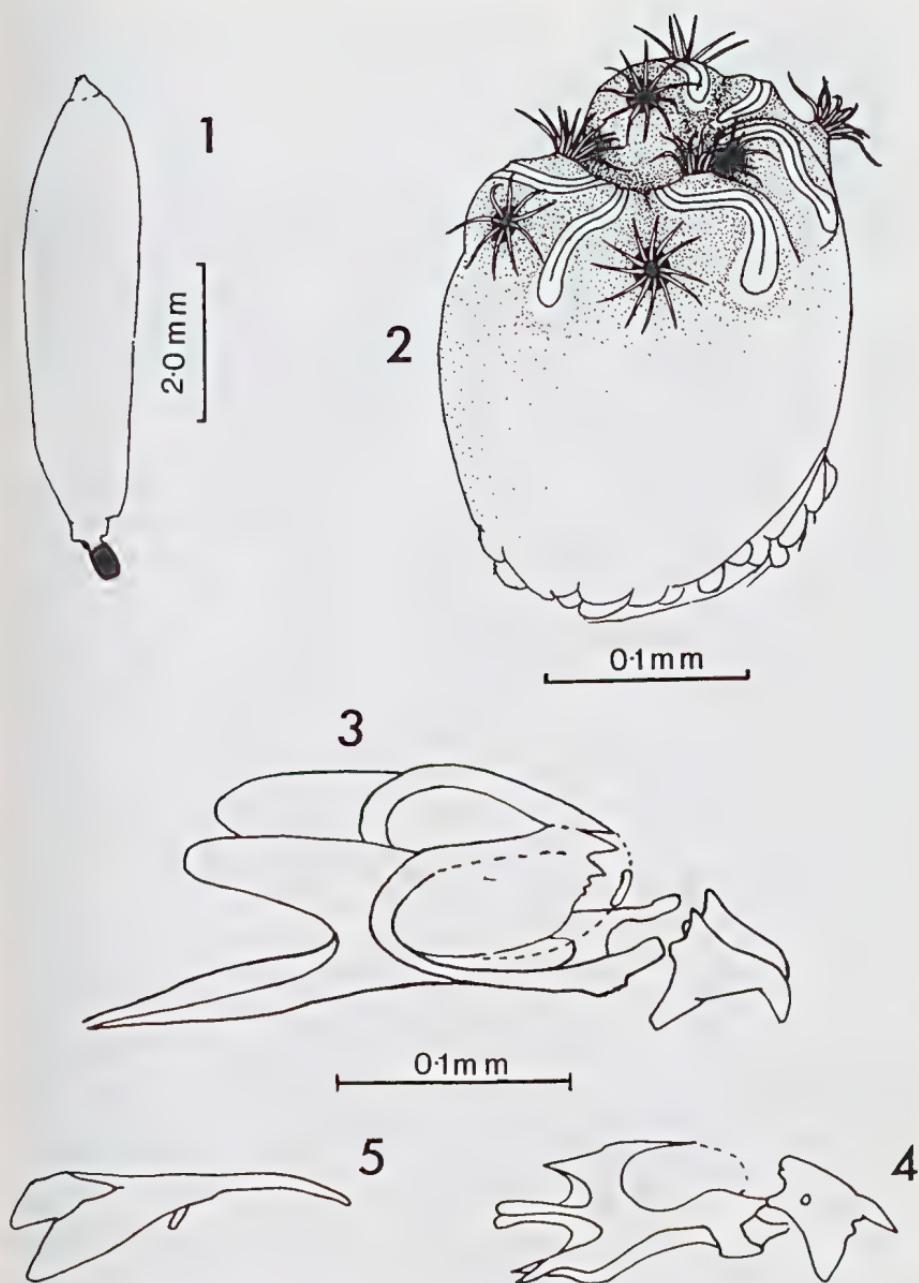
##### LARVA

There are three larval instars of *A. lepidofera* within the host. The first instar description is based on three specimens, the second instar on nine specimens and the third instar on seventeen specimens, dissected from *Nysius vinitor* (with one specimen from *Oxycarenus luctuosus*) and mounted on microscope slides. Further material retained in 70% alcohol as well as puparia from reared adult flies were also examined. All specimens are held in the Biological and Chemical Research Institute collection at Rydalmere.

*First instar:* Length 0.6-1.0 mm. Body semi-translucent white, cylindrical, slightly claviform tapering to blunt cylindrical posterior; with head and ten discernible body segments. Caudal spiracles small, separate, single lobed. Other spiracles not apparent. Pseudocephalon ringed with three to four loose rows of fine spinules; body segments I-II smooth; segments IV-IX inclusive each with six to seven transverse rows of small rounded tubercles anteriorly on the ventral third of segment's circumference; segment IX ringed posteriorly with three to four loose rows of fine spinules; segment X (caudal segment) sparsely covered with fine spinules excepting the bisected circular anal orifice. Buccopharyngeal armature simple, brown and smooth (Fig. 5).

*Second instar:* Length 1.5-2.0 mm. Body similar to third instar (Fig. 1). Segmentation indistinct. Caudal spiracles separate, rugose, bi-lobed, situated on apex of slightly raised, broad, unsclerotised posterior process; other spiracles absent. Last body segment ringed with five to seven irregular rows of spinules. Triangular spinule patch ventral to the spiracles. Buccopharyngeal armature (Fig. 4) brown, rugose, with slender oral hooks fused postero-ventrally to large dental and accessory sclerites. Pharyngeal sclerite long, broad; cornua small.

*Third instar:* Length 3.5-5.5 mm. Body robust fusiform (Fig. 1), creamy white with brown gut contents visible; segmentation indistinct. Integument smooth, caudal two segments narrower than preceding segments. Anterior spiracles



Figs 1-5. *Alophora lepidofera* (Malloch) larva: (1) third instar; (2) caudal spiracle of third instar; (3) buccopharyngeal armature of third instar; (4) buccopharyngeal armature of second instar; (5) buccopharyngeal armature of first instar.

absent. Caudal spiracular processes fused, globose-cylindrical, black, smooth with double band of small rounded tubercles near base; three raised slightly sinous spiracular slits and four slightly raised pores each side with nine to eleven pale setiform protrusions from each pore. Broad triangular patch of six to seven spinule rows ventral to spiracle; single row of spinules around spiracle. Anal orifice longitudinally slit-like, about one third as long as basal spiracular width, located nearly twice its length ventral to the spiracle, bordered each side by two infolded semicircular brown plates. Mildly raised integument tubercle each side of anus. Buccopharyngeal armature (Fig. 3) without apparent dental or accessory sclerites. Hypostomal sclerites fused to pharyngeal sclerite; dorsal cornua broader and shorter than ventral cornua in lateral view; cornua dark brown, oral hooks and hypostomal sclerites black. Infra-buccal area with patch of approximately twenty rows of spinules increasing in size anteriorly; ultra-buccal area lined with approximately seven rows of fine spinules; anterior oesophagus lined with rows of small tubercles.

**Puparium:** Length  $3.2 \pm 0.2$  mm. Elongate-oval, slightly bulbous anteriorly; dark red-brown. Spiracular process black, occasionally yellow on spiracular slits produced posteriorly to about 0.3 mm.

#### LIFE CYCLE

*Alophora lepidofera* was cultured in the laboratory, for only one generation, with *Nysius vinitor* and *N. clevelandensis* as the hosts. Copulation was observed within 24 hours of emergence and mostly took place in the morning. It commences with the male mounting the female, grasping her head with his fore legs and her thorax with his mid and hind legs. During copulation the female pushes her head upwards and the male pushes it downwards resulting in rhythmic up and down movement. The flies neither flew nor fed during copulation. Each pair observed copulated two to three times and copulations lasted between 10 and 46 minutes.

Emerged flies fed on dilute honey solution placed in the cages and a mated female fly was dissected daily from one to four days after copulation. The most mature eggs found at the apices of the ovaries were elongate-oval shaped and translucent white. No hatched larvae were found in fly dissections and the lack of progressively developing eggs in the uterus suggests that *A. lepidofera* is probably oviparous as are its close relatives *Hyalomya* species (Clausen 1940). The state of the ovaries was very similar between the different days of dissection. This, and the short adult life (six to eight days at  $25 \pm 2^\circ\text{C}$ ), indicates that *A. lepidofera* adults mature rapidly after emergence.

Oviposition was not observed in the laboratory. Larvae were dissected from both host species placed with mated female flies but the oviposition method and fecundity remain unknown.

First, second and third instar larvae were all found with their posterior end just in the metathoracic segment with the anterior end aligned along the abdomen. Third instar larvae are attached to a metathoracic trachea close to the spiracle by means of a respiratory funnel. All three instars are metapneustic

and most gas exchange is probably through their posterior spiracles because of the chitinous sheath the host forms encasing the larva. The respiratory funnel is nearly half the full grown larval length. It usually contains remains of the second instar buccopharyngeal armature and also occasionally that of first instar. This suggests that all three larval instars have a respiratory funnel.

The main host tissue eaten is the fat body in both sexes and the ovaries in females. Parasitism by *A. lepidofera* therefore renders female hosts incapable of reproducing. Adult females are more often hosts to the extent that 95.2% of parasites were from females, 4.8% from males and none was from nymphs (Attia 1973). Preference for female hosts is not uncommon in Tachinidae and is also noted in *Hyalomya aldrichi* (Clausen 1940).

Multiple parasitism by *A. lepidofera* has been observed only once, when one large and two small *A. lepidofera* larvae were dissected from a female *N. vinitor* at Tamworth, N.S.W. Mermethid nematode worms have been found on rare occasions in the same *N. vinitor* as larvae of *A. lepidofera*. It is not known in these cases of multiple and mixed parasitism whether or not the parasites reach maturity.

Larvae emerge from female hosts, through the intersegmental region between the 7th and 8th sternites in females with the end segments pushed upwards perpendicular to the abdomen. In male hosts the larvae emerge through either the end of the abdomen or through a fracture between prosternite and mesosternite. The hosts die within two hours of parasite emergence. On emergence the larvae are active, move rapidly and form puparia within approximately five hours. The observed larvae did not seem to seek concealment and pupated on the surface of light loam soil, partly hidden under the soil surface or in the heads or on the leaves of sunflowers in the cages.

Mature larvae left their hosts and pupated ten days after the latter had been exposed to mated female flies. The pupal stage occupies ten days for female flies and nine days for male flies. The life cycle of *A. lepidofera* in the laboratory at  $25 \pm 2^\circ\text{C}$  therefore took about 21-25 days to complete, allowing five days for adult maturity and oviposition. This period as a pupa is consistent with that of five to seven days for *H. aldrichi* in summer (Clausen 1940) and of eight days for *Allophora pusilla* Meig (Eyles 1963). Nothing is known of the life cycle duration in the field or whether a quiescent stage exists. All field records of parasitism so far have been in spring and summer months between August and February. *Nysius vinitor* and *N. clevelandensis* overwinter as adults and it is possible that *A. lepidofera* has an extended larval duration inside the host during winter months.

### Discussion

The first instar larva (see description) is 'tachiniform' (Clausen 1940) and there are some structures which allow speculation as to its entry into the host. The thin, unpigmented skin suggests that the larvae are not long, if at all, outside their hosts. However, the patches of small tubercles on the ventral surface of body segments are in the form of "creeping welts" which suggest

that the larvae are capable of moving on a surface. The buccopharyngeal armature does not seem as robust as those found in larvae such as *Centetor cinerea* (Clausen *et al.* 1927) which are known to penetrate an adult host's integument from the outside. The single smooth hook of *A. lepidofera* appears better suited to tearing a tracheal wall.

The respiratory funnel, arising from the host's main trachea near the metathoracic spiracle, is evidently present (see life cycle) during the first instar. Therefore, the first instar larva possibly either: enters the host through this main trachea, initiating a primary respiratory aperture; /or seeks this position to penetrate the trachea initiating a secondary respiratory aperture (Keilin 1944) if it hatches from an egg oviposited within the host. The latter seems unlikely to the authors because of the lack of sclerotised armament on the caudal end, often found in larvae which form a secondary respiratory aperture (Clausen 1940, Keilin 1944). However, this cannot be dismissed considering that the last abdominal sternite of female adults is modified into a sclerotised beak (illustrated by Malloch 1930) which could possibly serve to puncture the integument during oviposition.

The posterior spiracles of third instar larvae of *A. lepidofera* are distinct from those of other tachinid larvae examined and from those previously described, in having pores with setiform protrusions. These pores are probably analogous to the tubercles possessing hydrophobic hairs found on the spiracles of other Schizophora larva. However, their function implied by this analogy, of preserving spiracular access to air at a liquid interface seems anomalous considering the spiracular encasement within a respiratory funnel. Examination of the spiracles at high magnifications with both a scanning electron microscope and a light microscope shows the pores to be quite deep and the setiform protrusions to arise from a common membranous base within the pore.

The immature stages described and figured show negligible variation in morphology amongst the specimens examined. This indicates that morphological variation, if found in similar larvae, can be interpreted as interspecific rather than intraspecific. In support of larval differences indicating different species in Tachinidae, Thompson (1922) reported three distinct larval types from different hosts corresponding to adult flies identified as conspecific by a taxonomist working on Tachinidae at that time. The adults were subsequently determined to be three distinct species. It is possible that the larvae of other *Alophora* species resemble those of *A. lepidofera*, yet differ in some of the characters used to describe *A. lepidofera*.

It is not uncommon for species of *Alophora* to have more than one host (Crosskey pers. comm. 1973) and *Alophora lepidofera* may have potential hosts other than the three already recorded. The Australian *Nysius* species are likely to have other tachinid parasites and the sampling areas in New South Wales (Attia 1973) represent only part of their range, although in Attia's dissections and approximately 26,000 *Nysius* dissections done from 1975 to 1980 (N. W. Forrester pers. comm.) *A. lepidofera* was by far the most abundant parasite.

A tachinid first instar larva in the 'planidium' category of Clausen (1940) has been dissected from *Nysius vinitor* at Tamworth N.S.W. This type of larva differs greatly from the 'tachiniform' first instar of *A. lepidofera*, being eight segmented with dark pigmented plates covering its entire integument and having more complex buccopharyngeal armature. Attia (1973) found no 'planidia' in his *Nysius* dissections and only on two subsequent occasions have these larvae been found (N. W. Forrester pers. comm.). Considering their rarity and the lack of mature larvae different from those of *A. lepidofera*, the authors suspect that they are of a species which does not normally invade *Nysius vinitor* as its host.

### Acknowledgements

The authors thank Dr R. W. Crosskey of the British Museum (Natural History) for identification of the specimens and his personal communications on the taxonomy of the group, Mr N. Forrester of Tamworth Agricultural Research Centre for providing useful specimens and Dr M. J. Fletcher, Biological and Chemical Research Institute for his useful criticism of this manuscript.

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## AUSTROCAECILIUS, A NEW GENUS OF CAECILIIDAE (PSOCOPTERA) FROM AUSTRALIA

By C. N. Smithers

The Australian Museum, 6-8 College Street, Sydney, N.S.W. 2000

### Abstract

A new genus *Austrocaecilius*, is described from Muogamarra Nature Reserve, near Sydney. It is related to *Caecilius* Curtis, but has several morphological peculiarities in the terminal structures of the abdomen of the female.

### Introduction

Material collected during a study of the Psocoptera of Muogamarra Nature Reserve, near Sydney, New South Wales, included a single female previously referred to as "?Caeciliid gen. et sp. n." (Smithers 1977). As the slide preparation of the specimen was not satisfactory the species was not described; repeated attempts to obtain more material have failed. Remounting the specimen has resulted in a more satisfactory slide and it has been decided to proceed with the description of this specimen which represents an interesting new genus and species.

### *Austrocaecilius* gen. nov.

Belonging to the Caeciliidae (*sensu* Mockford 1978) with the following combination of features: Antero-lateral setae of labrum a little heavier than others; mandibles elongate; fore wing setae short, in one row on veins; wing membrane not setose; anterior labial sensilla absent; female subgenital plate with exceptionally well developed lateral apophyses; clypeal shelf very narrow; labral stylets present; lacinial tip broad; no sclerotized ridges across labrum; no preapical tooth on claws; ventral and dorsal valves of gonapophyses long and pointed; external valve well developed, elongate, strongly sclerotized, without setae; glandular area on spermathecal duct very long, along almost whole length of duct.

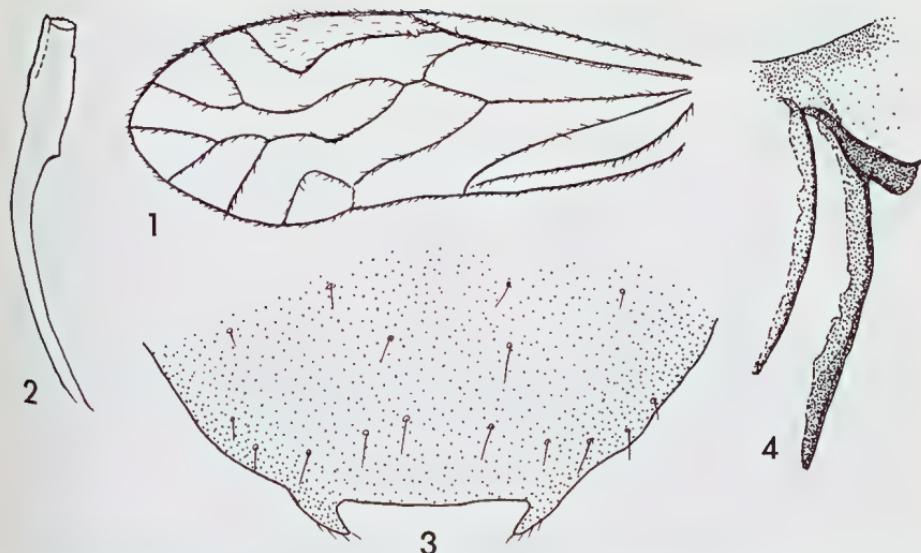
Type species: *Austrocaecilius alettae* sp. n.

### *Austrocaecilius alettae* sp. n.

#### FEMALE

*Coloration* (in alcohol). Head brown, shiny. Median epicranial suture dark brown. Antennae pale brown. Eyes black. Maxillary palps very pale brown, apex of fourth segment a little darker. Thoracic nota brown, shiny, the area where the lateral lobes of the mesothorax meet a little paler so that the thorax appears to have a small pale patch in the middle when seen from above. Legs pale brown. Fore wings (Fig. 1) hyaline, tinged with brown but slightly paler in middle of cell  $R_5$ , at  $Cu_{1a}$  and at nodulus. Veins brown. Hind wing hyaline, slightly tinged with brown; veins brown. Abdomen pale brown.

*Morphology.* Length of body: 2.1 mm. Median epicranial suture very distinct. Head with short but fairly dense pubescence, even on genae. Postclypeus fairly bulbous. Length of flagellar segments:  $f_1$ : 0.52 mm;  $f_2$ : 0.38 mm;



Figs 1-4. *Austrocaecilius* gen. nov. et sp. n. (1) ♀ fore wing; (2) ♀ lacinia; (3) ♀ subgenital plate; (4) ♀ gonapophyses.

second segment relatively short. Antennae shorter than fore wings. Eyes fairly large, almost reaching level of vertex. IO/D (Badonnel): 1.9; PO: 0.77. Ocelli of almost equal size but fairly small. Lacinia (Fig. 2): Trochanters and femora with fine long setae. Measurements of hind leg: F: 0.59 mm; T: 1.0 mm;  $t_1$ : 0.31 mm;  $t_2$ : 0.13 mm; rt: 2.4 : 1; ct: 19, 0. Hind tibiae a little broadened distally. Fore wing length: 2.8 mm; width: 1.2 mm. Costa broadened in pterostigma and towards wing apex. Pterostigma with posterior angle, with concave hind margin. Rs and M strongly sinuous before bifurcation. Areola postica fairly tall, reaching more than halfway to M.  $Cu_1$  slightly sinuous,  $Cu_2$  setose. Hind wing length: 2.2 mm; width: 0.8 mm. Venation and setae as usual in *Caecilius* Curtis. Epiproct simple, rounded behind, with a few scattered setae. Paraproct with large field of trichobothria and a few scattered setae near hind margin. Marginal cone and seta apparently absent. Subgenital plate (Fig. 3) lightly sclerotized with lobe at each end of the hind margin between which the margin is slightly curved outwards; each lobe with a few small setae on outer margin near end. Gonapophyses (Fig. 4) with three valves; ventral and dorsal valves long, ending in a blunt point; external valve well sclerotized, developed into a curved, distally broadened plate ending in a small pointed extension of the dorsal border; the basal attachment of the gonapophyses well sclerotized. Glandular tissue along spermathecal duct extends almost whole length of duct.

MATERIAL EXAMINED. NEW SOUTH WALES: 1♀ (holotype) Muogamarra Nature Reserve, 23.v.1973 (C. N. and A. S. Smithers) (Australian Museum collection). [This specimen previously referred to as "? Caeciliid gen. nov. et sp. n." (Smithers 1977)].

This species is named for my wife in appreciation of her assistance in the field over many years.

## DISCUSSION

Mockford (1976) has discussed the four groups of families traditionally recognized in the suborder Psocomorpha and summarized their characteristics. *Austrocaecilius* clearly belongs to the group Caecilietae established by Pearman (1936) for a large number of species which show considerable morphological similarity. Within the Caecilietae Mockford (*loc. cit.*) established two superfamilies, the Asiopsocoidea and the Caecilioidea. In the former superfamily he included only *Asiopsocus* Gunther and *Notiospocus* Banks (both in the Asiopsocidae) placing all other genera of the Caecilietae in the Caecilioidea, that is, all genera previously placed in the Caeciliidae, Stenopsocidae, Amphisocidae and Polypsocidae. Later (Mockford 1978) he discussed reasons for considerable rearrangement of these genera, set out a classification of reconstituted Amphisocidae and established the characters of that family, the Caeciliidae, and an additional family, not yet named, based on his "Genus IX". He did not discuss the fate of those genera of the Caecilioidea which he did not include in these three families, but by inference they are placed in his Caeciliidae.

*Austrocaecilius* agrees with several characters of his unnamed family but differs in having a well developed, sclerotized external gonapophysis valve. It conforms to his characterization of the Caeciliidae but not Amphisocidae. Only in the female genitalia is there some resemblance to the amphisocid genera *Dasydemella* Enderlein and *Matsumuraiella* Enderlein in that both have a fairly well developed external valve but as well as differing in most features listed by Mockford (1978) they also differ in having the setae on the fore wing veins in two rows (one in Caeciliidae and *Austrocaecilius*). Also, in contrast to *Austrocaecilius*, *Matsumuraiella* has setae on the fore wing membrane as well as on the veins and wing margin. *Austrocaecilius* should be placed in the Caeciliidae.

Within that family the extent of the very well developed lateral apophyses of the subgenital plate, carrying setae, and the well developed external valves of the gonapophyses are seen in no other described genus.

## Acknowledgements

I would like to thank the Director of the National Parks and Wildlife Service for permission to work in Muogamarra Nature Reserve and my wife for assistance in the field.

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## THE CULTURING OF *JALMENUS EVAGORAS EVAGORAS* (DONOVAN) AND ITS ATTENDANT ANT, *IRIDOMYRMEX ANCEPS* (ROGER)

By R. L. Kitching and M. F. J. Taylor

School of Australian Environmental Studies, Griffith University, Nathan, Qld. 4111

### Abstract

Techniques for maintaining an on-going laboratory colony of the myrmecophilous lycaenid, *Jalmenus evagoras*, and its attendant ant, *Iridomyrmex anceps*, are presented and discussed.

### Introduction

In recent years there has been something of a renaissance in the study of the relationships between lycaenid larvae and pupae and ants. This is, in part, a consequence of the somewhat provocative paper of Malicky (1970) on the advantages and disadvantages of the association to both ant and butterfly. In addition, the new theoretical directions in the study of mutualism sketched, initially, by May (1976) have turned the attention of the population ecologist as well as the lepidopterist to these fascinating interactions.

For the size of our lycaenid fauna, Australia is particularly well-endowed with myrmecophilous or presumed myrmecophilous species (Common and Waterhouse, 1972; Kitching, in press). With all of these considerations in mind, we began in 1978, a detailed study of the morphology, behaviour and population dynamics of the common wattle-feeding lycaenid, *Jalmenus evagoras evagoras* (Donovan) and its attendant ant, *Iridomyrmex anceps* (Roger) basing our field work on colonies of butterfly and ant occurring at Mt. Nebo near Brisbane, Queensland.

In order to make a detailed investigation of the biology of any species of insect it is almost essential to be able to maintain cultures of the species in the laboratory so that all stages are accessible and of known history when required for experimental work. Although, as most lepidopterists are aware, *J. evagoras* is easy to rear from larvae to adult, to complete the cycle and produce generation after generation in the presence of the ant, is far less straight forward. We have developed techniques for culturing the pair of species and present them here in the hope that this may lead others to establish such cultures. The two species involved are sufficiently common to have potential both as teaching and research material, illustrating as they do a most dramatic and interesting natural interaction.

### The insectary

We maintain our ants, butterflies and foodplants in a 4 m x 4 m x 2 m shade-house constructed of steel piping with a translucent fibreglass roof and a cement floor. The walls are of 30% shade cloth stapled to the inside of a timber substructure tied to the metal frame. A shade cloth curtain also screens the outer door. We subdivided the shade-house into a inner 1.5 m x 4 m x 2 m culture room and an adjacent service area and our butterflies fly free within this inner area (see below). The shade-house is provided with low (0.5 m high) plant benches of angle iron and stout weldmesh construction and, of those on which

ants are maintained, the bench legs sit in pots containing oil or detergent to prevent egress of the ants. Fig. 1 is a view of the culture room inside the insectary.

### Food plants

Larvae of *Jalmenus evagoras* feed on the foliage of a variety of species of *Acacia* appearing to prefer the compound-leaved varieties, although they are by no means restricted to them. In the Brisbane region the principal food plant is *A. irrorata* Sieb. ex Spreng. and it is this species and *A. decurrens* Willd. that we have used in our cultures. Plants of *A. irrorata* were collected during the winter when 5-10 cm tall and kept in the shade-house for use in the ensuing summer season. We note in the field that butterfly larvae are absent from bushes greater than 2 m in height, and, in fact, have discarded plants in our culture when they exceed 1.5 m. On occasion, we have used nursery-bred *A. decurrens* as substitutes for field-collected *A. irrorata* and the larvae and ants have thrived equally well on this species.

To restrict ants to particular plants we place plant pots on rubber stoppers in trays of oil as shown in Fig. 2, making sure the base of the pot is above the level of the oil. We have found that ants will infest the soil of a pot if allowed contact with it, abandoning the plastic formicaria provided (see below). This can be prevented by stretching plastic sheeting or nylon mesh over the top of the pot and stapling, tying or sticking it in position, although the use of nylon is, at best, a temporary expedient as the ants will gnaw their way through it within a week.

### The ants

The primary attendant of *Jalmenus evagoras* is *Iridomyrmex anceps*. This ant is highly polydomous and the main brood chamber is usually more than 20 cm below the soil surface. We attempted to remove nests whole, by digging them out and transferring them in large plastic bags. It proved difficult to obtain queens; only one excavation out of about ten was successful, this nest being in loose soil on a steep slope. The species is apparently polygynous as our most successful excavation gave us an entire nest in which there were three queens.

The collected nest can be kept for at least several days in its bag in a cool room. We tried manual sorting of cooled ants but this method is unnecessary and tedious and inefficient. As an alternative, we spread the cooled nest out over a large table covered in plastic and surrounded by a plastic strip coated with Tanglefoot®. Several formicaria (see below) are moistened liberally, covered with aluminium foil with one entrance left open and left at various locations on the table. The ants, when they warmed up, regroup themselves and collect their scattered brood into the moist, dark formicaria. After one day, the formicaria could be closed up and the sub-colonies so obtained, removed.

Our standard culture uses formicaria of a design provided by Dr R. W. Taylor. These comprise a perspex dish constructed with a central hole in its base which is filled with plaster of Paris. The sides of the dish are pierced for three (or more) exit tubes which can be stoppered or connected with other



Figs 1, 2. (1) view of the *Jalmenus* rearing room showing food plants and oil trays; (2) a single food plant equipped with ant excluder (above soil) and formicarium addressed to the stem. Pupal debris and branches stripped by feeding larvae can be seen.

units. A tight-fitting lid completes the unit. The formicaria are maintained on a moistened pad (filter paper will suffice) so that the plaster of Paris remains moist. They are covered with metal foil and kept in an open plastic lunch box, the sides of which are coated with the anti-friction lacquer Fluon®. The formicaria are equipped with about a tablespoon of soil to allow the ants to have some control over nest humidity. Originally the colonies were fed on honey solution and dead spiders, however, we now use a totally liquid diet of 5:8 honey: water (effectively 50% sugars) mixed 2:1 with egg yolk (50% protein, 20% fat). A small colony (50 workers and 20 larvae) will go through about 0.1 ml/day during alate production. The feeder solution is administered in small 10 mm lengths of 5 mm plastic tube, which are filled from a syringe. Clear tubing allows inspection of amounts of food remaining. The tubes are discarded after use.

Adult ants will last the winter without feeding. One small queenless colony in fact persisted with 47 adults, 12 pupae and 19 larvae from April to September unfed—they may however have eaten away at a larger initial brood or derived nutrition from small organisms in the soil which was included in their formicarium.

Handling, transferring and mixing the colonies is best achieved by anaesthetizing them with CO<sub>2</sub>. This keeps the adults inactive for up to a minute. These ants are prone to nest shifting, and brood will be transported by workers on the slightest disturbance. As already mentioned, given the choice of soil or formicarium, the colony will choose soil. To avoid this, the soil surface in pots must be covered to prevent invasion unless having the colony in the pot presents no disadvantage.

Ants were allowed access to the food plants by placing a formicarium with its only exit adpressed against the base of the shrub (Fig. 2).

### The butterflies

The laboratory colony was established by bringing in from the field cut-stems of the food plant together with attached clusters of larvae and pupae. These stems were tied against branches of the potted wattles in the culture room and the attached larvae transferred themselves to the living foliage within twelve hours. These immature stages, tended by the ants which had access to the trees, produced the first generation of adults. In addition, overwintering egg batches have been brought in on occasion, incubated, and the hatchlings transferred to host trees.

Adults will mate shortly after emergence even in restricted spaces (initially we had them in 0.5 x 0.5 x 1.0 m gauze cages) but we obtained no oviposition in such confinement. Only when we established our cultures, free-flying, in the much larger culture room did oviposition follow mating. In the field, on the more weathered wild host shrubs the egg-laying females usually seek out crevices in the bark in which to lay their batches of up to 20-30 eggs. In the case of our cultured shrubs, which had smooth, undamaged bark for the most part, we found that suitable crevices for oviposition could be manufactured either by making slits in the bark with a scalpel or, more conveniently, by binding small sections of the stem with a rough, fibrous string. The butterflies

accepted this latter expedient readily as an alternative site for oviposition. It has been our impression also that oviposition was more likely on those shrubs which still had either living immature stages on them or the debris from such stages in the form of larval exuviae or pupal skins. We are currently carrying out choice-experiments to determine the relative attractiveness of trees with and without pupal debris and/or ants and the results of these will be reported in due course.

Adult feeders were provided in the culture room and were made from ranks of four 5 mm glass tubes mounted vertically in wooden blocks, each surmounted by a plastic corolla (culled from commercially available plastic flowers) and a small cube of sponge. The tubes are maintained full of 50% aqueous hoeny solution which is absorbed by the sponge and from which the butterflies feed readily. Butterflies will feed from petri dishes containing cotton wool pads soaked in honey solution but the feeders described seem to provide a more accessible and reliable food source for them.

#### General comments

We maintained the culture of *J. evagoras* and its attendant ants in the manner described above throughout the summer of 1978-79 during which period it provided ample material for experimental and morphological work. At the end of the summer season the adults laid diapausing eggs and, in this fashion, the colony survived over the winter, the overwintering eggs hatching and seeding the following summer's colony. The culture is still in good health and we feel confident it can be so maintained. Periodically we have brought in further material from the field to obviate any problems of low vigour in the laboratory arising from inbreeding.

The species involved present many opportunities for work on various aspects of the butterfly, the ant and the interaction between the two. We commend them both as research and teaching tools.

#### Acknowledgements

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## AN UNDESCRIPTED AND POSSIBLY EXOTIC BEETLE (SCARABAEIDAE: DYNASTINAE) OCCURRING ON THE SOUTH COAST OF NEW SOUTH WALES

By P. B. Carne

CSIRO Division of Entomology, P.O. box 1700, Canberra City, A.C.T. 2601

### Abstract

The presence of a possibly exotic dynastine scarab is reported from the Moruya, Tuross and Bega districts of New South Wales. It belongs to an undescribed genus most closely related to the monospecific *Calicnemis* which is endemic to the western Mediterranean region and the French Atlantic coast. Collectors visiting the south coast of New South Wales are encouraged to seek additional specimens, the species presently being known only from three females.

### Introduction

While checking accessions to the Australian National Insect Collection, two female specimens of a remarkable dynastine scarab were noted. These possess characters which readily distinguish them from any known indigenous species and they were presumed to be of exotic origin. One specimen was sent to Mr R. D. Pope of the British Museum (Natural History) who subsequently referred it to Dr Roger-Paul Dechambre of Paris. Dr Dechambre expressed the view (pers. comm., 1978) that the species represents a genus closely similar to *Calicnemis* Castelnau which occurs in the western Mediterranean region. A third female specimen, collected seventy five years ago, was subsequently located in the collections of the New South Wales Department of Agriculture, Biological and Chemical Research Institute.

### Material examined

NEW SOUTH WALES: Moruya Heads, coastal sand dunes, walking on surface towards dusk, 24.iii.1968 (K. Pullen), 1 ♀; Tuross Beach, 16 km S of Moruya, 26.i.1979 (S. Misko), 1 ♀ (both in ANIC); Bega, 9.iii.1905 (Edwards), 1 ♀ (N.S.W. Dept. of Agriculture).

### Morphological characters

The beetles (Figs 1-3) are 12-14 mm in length, and a medium reddish brown in colour. The combination of characters which distinguish this species from all known indigenous Dynastinae is: clypeofrontal suture obliterated, the whole head with coarse concentric sculpturing (Fig. 1); antenna very short, 9-segmented; pronotum impunctate; foretibia with apical and single lateral tooth smoothly rounded; hind leg remarkably broad, strongly compressed (Fig. 2), and the tibia (Fig. 3) with sculpturing similar to that of head; all tarsi unusually short.

Dr Dechambre reported that the species is undescribed. Although it is very similar to *Calicnemis latreillei* Castelnau, the only known species in that genus, characters of antennal segmentation and the structure of the clypeus and maxilla indicate that the Australian species is generically distinct. *C. latreillei* inhabits beaches around the Mediterranean and on the southern French



1



2



3

Figs 1-3. Specimen from Tuross Beach, N.S.W.: (1) dorsal view of head and pronotum; (2) lateral view of whole insect; (3) ventral view of whole insect.

Atlantic coast. Sexual dimorphism in *C. latreillei* (as in a great many Dynastinae) is quite marked, the pronotum of the male bearing an anteromedian tubercle preceded by a depression of the pronotal disc.

### Discussion

Caussanel and Dajoz (1967) gave an account of the biology and behaviour of *C. latreillei*. The beetle breeds in decaying timber submerged in beach sands. Prior to their studies adults had been collected only rarely as they emerge for flight 10-15 minutes after sunset, flights persist for no more than 20-25 minutes, and occur only on evenings when the air temperature and relative humidity exceed 15°C and 70 percent respectively; moreover, the insects are not attracted to lights. These workers succeeded in capturing a large number of specimens (over 500, with males predominating) by erecting a fine-mesh fishing net, 30 m long and 2 m high, across a beach, and (presumably) by picking up beetles which fell to the sand after colliding with the net.

The close similarity between the Australian species and *C. latreillei*, including the highly modified hind leg, suggests that their habits might be similar. If this is so, it could account for the fact that only three specimens are known, although the insect occurs in a well-collected area. It may, in reality, be quite abundant on the south coast of New South Wales, but have habits that make its capture by conventional collecting methods unlikely. The insect is so markedly different from any known Australian dynastine that the writer suspects that it may not be indigenous to this country. A littoral beetle, such as this species appears to be, could easily have been transported to Australia from overseas in ship's ballast of beach sand.

It is hoped that entomologists who visit the area during warm, humid weather in the January-March period will feel challenged to seek this interesting insect. It is highly desirable that males should be available for study before the new genus and species are described.

### Acknowledgements

I am grateful to Dr E. Schicha of the N.S.W. Department of Agriculture for the loan of the specimen from Bega, and to Mr Pope and Dr Dechambre for comments on the insect.

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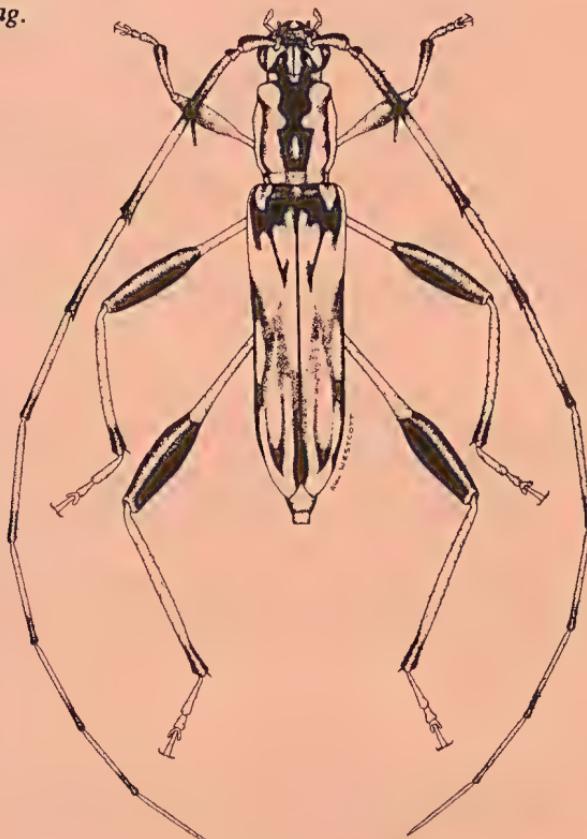
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## COVER

Illustrated by Alan E. Westcott.

Depicts the citrus longicorn, *Skeletodes tetrops* Newman, the larvae of which are commonly found in decaying citrus wood in eastern New South Wales. Eggs are laid in dead bark, usually after damage by other longicorn species, and the larvae make shallow tunnels packed with flour-like frass. The species is not considered to be economically significant.

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## FURTHER RECORDS OF *MACROSIAGON* (COLEOPTERA: RHIPIPHORIDAE) REARED FROM EUMENID AND SPHECID WASPS IN AUSTRALIA

By E. McC. Callan

13 Gellibrand Street, Campbell, Canberra, A.C.T. 2601

### Abstract

*Macrosiagon capito* (Blackburn) and *M. novaehollandiae* (Gerstaecker) are reported as parasites of the eumenid wasps *Eumenes latreillei* Saussure and *Odynerus* sp. respectively, and *M. semipunctatum* (Lea) as a parasite of the sphecid wasp *Sceliphron formosum* (F. Smith).

### Introduction

Parasitic beetles of the family Rhipiphoridae are well represented in Australia, where the genus *Macrosiagon* Hentz parasitizes wasps of the families Scoliidae, Tiphidae, Eumenidae and Sphecidae (Callan, 1977). Hosts are known in Australia for six species of *Macrosiagon*. Four species reared from eumenid and sphecid wasps, which build mud nests, are discussed below.

#### *Macrosiagon capito* (Blackburn)

This species was described in the genus *Emenadia* Laporte from Victoria (Blackburn, 1899). It was characterized as entirely ferruginous red above and entirely black beneath, with the front half of the head black and the hind half red.

A male, reared from the mud nest of the eumenid *Abispa* sp., but without precise locality, was recorded in an earlier note (Callan, 1977). I now report two further specimens, a female and a male, both reared from eumenid wasps. The female was reared from *Eumenes latreillei* Saussure, Darwin, Northern Territory, 30.iv.1976 (A. Smith). *E. latreillei* is a potter wasp, common in Northern Australia, about 22 mm long, with a distinctly petiolate gaster, and builds characteristic, globular, mud nests often on the walls of buildings.

The male was reared from the eumenid *Odynerus* sp., occupying an old nest of *Paralastor* sp., Darwin, N.T., xii.1976 (A. Smith). The *Odynerus* sp. is 12 mm in length. Dr I. D. Naumann kindly examined a specimen and confirmed the generic identification on wing venational characters. Mr Andrew P. Smith

informed me (1980, *in litt.*) that this species is a 'renter' in old mud nests, including those of *Eumenes* and *Paralastor*.

Individuals of the same species of *Macrosiagon* often vary considerably in size. In this case the female was distinctly larger than the male, the size difference being correlated no doubt with the different sizes of the eumenid hosts. It is probably significant that *M. capito* has so far only been found parasitizing Eumenidae.

#### *Macrosiagon novaehollandiae* (Gerstaecker)

This species was described originally in the genus *Rhipiphorus* from New Holland (Gerstaecker, 1855). Lea (1917) commented on some of its structural features and variable markings, and recorded specimens ranging in length from 4 to 9 mm from South Australia and Western Australia. I have seen Gerstaecker's description of the female, which occupies 10 lines of Latin. The specimen reported below agrees tolerably well with this description and keys out to this species in Blackburn (1899).

An individual (headless) of unknown sex, which appears to be *M. novaehollandiae*, was reared from the eumenid *Eumenes bicinctus* Saussure, Clive Downs, Tiboburra, N.S.W., xii.1973 (A. Smith). The specimen is mounted with the reddish brown subspherical mud nest (diameter 13 mm) from which it emerged. *E. bicinctus* is a potter wasp, widespread in Australia, rather smaller than but similarly marked to *E. latreillei* and, like this species, building globular mud nests on walls and in other sheltered situations.

#### *Macrosiagon semipunctatum* (Lea)

This species was described in the genus *Emenadia* from NW Australia (Lea, 1904). It is black with red abdomen, antennae, palps, spurs and claws. The elytra are pale, each with three conspicuous black maculae. There are specimens in the Australian National Insect Collection, C.S.I.R.O., Canberra from Western Australia, Northern Territory and New South Wales.

I now report a male of *M. semipunctatum* reared from the spcid wasp *Sceliphron formosum* (F. Smith), Tipaminka, Brooks Road, Binnaway, N.S.W., iii.1975 (A. Smith). *M. diversiceps* was reported as a parasite of a spcid wasp (Callan, 1977), and this is the second instance of a rhipiphorid parasitizing Sphecidae in Australia.

*S. formosum* is a mud-dauber wasp belonging to the spcid subfamily Sphecinae, tribe Sceliphronini, and is known from Australia, Papua New Guinea and Indonesia (Moluccas to Ceram and Ternate). It builds a mud nest of several cells in protected situations, each cell being provisioned by the female with spiders as food for the developing larva.

As old *Sceliphron* mud nests are often occupied by eumenid wasps, I thought there was a possibility that the *Macrosiagon* might have attacked a eumenid rather than *Sceliphron*. Mr Andrew P. Smith informed me (1980, *in litt.*) that the *Sceliphron* nest from which he reared the *Macrosiagon* was fresh, being recently constructed, and the parasite had pupated within the actual

completed cocoon of its *Sceliphron* host. So there can be no doubt that the host was *S. formosum* and not a later eumenid occupant of the nest.

### Discussion

Six species of Rhipiphoridae of the genus *Macrosiagon* have been reared from aculeate wasps in Australia. *M. cucullatum* (Macleay) and *M. punctulaticeps* (Blackburn) parasitize ground-nesting Scoliidae and Tiphidae respectively. The other four species have been reared from wasps which build mud nests; *M. capito* and *M. novaehollandiae* from Eumenidae, and *M. diversiceps* and *M. semipunctatum* from Sphecidae.

*Macrosiagon* is well known as a ubiquitous parasite of Eumenidae, but records of Sphecidae as hosts are comparatively rare (Callan, 1977). In Australia the sphecid genera *Pison* and *Sceliphron* and elsewhere *Stizus*, *Bembix*, *Trypoxylon* and *Trigonopsis* are known to be parasitized. *Stizus* and *Bembix* are ground-nesting wasps and the other genera build mud nests. Most records seem to be of builders of mud nests (Eumenidae and Sphecidae), but this probably only reflects the fact that these wasps are more often reared, and in greater numbers, than fossorial wasps.

The host associations of relatively few *Macrosiagon* are known with certainty. Krombein (1967) presented an account of the North American *M. cruentum* (Germar), which he reared from several species of eumenid wasps. He regarded eumenids as the preferred, and perhaps the only, hosts. Snelling (1963) reared the same species from a eumenid nest in an old nest of the mud-dauber *Sceliphron caementarium* (Drury). However, he suggested that the latter might regularly serve as the host, and that parasitism of the eumenid was accidental. It is of particular interest, therefore, that in the record of the Australian *M. semipunctatum*, the host from which it was reared was definitely *S. formosum*.

### Acknowledgements

I am grateful to Mr Andrew P. Smith for sending me the reared specimens of *Macrosiagon*, which have been deposited in the Australian National Insect Collection, C.S.I.R.O., Canberra, and to Dr E. B. Britton for help in the identification of the species.

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## FOOD PLANT RECORD FOR *CRURIA DONOWANI* (BOISDUVAL) (LEPIDOPTERA: AGARISTIDAE)

By David K. McAlpine

The Australian Museum, 6-8 College St, Sydney, N.S.W. 2000

### Abstract

Larvae of *Cruria donowani* (Boisduval) are recorded damaging cultivated plants of *Alocasia macrorrhizos*.

### Introduction

*Cruria donowani* (Boisduval, 1832) is widely distributed in eastern Australia and occurs also in Northern Territory and Timor. The species was first described by Boisduval as "A. (-gariste, *Agarista*) de Donowan, *Donowanii*." Subsequent authors except Jordan (1912) have generally used the emended spelling *donovani* for the specific epithet.

### Food plants

The larvae were found in numbers through December 1979 eating leaves and petioles of *Alocasia macrorrhizos* (family Araceae, "Cunjevoi" or "spoon lily") cultivated in an open glass-house at Willoughby, a suburb of Sydney. A few larvae placed in a jar pupated in cells in loose soil. Adults emerged, two on 2 January and one on 4 January 1980. The larvae were very destructive to the plants and continual hand-picking was necessary to prevent serious damage. Agaristid larvae, probably of this species, were largely responsible for the death of young *Alocasia* plants at Willoughby several years earlier. They tunneled in the petioles and growing points and the plants subsequently rotted. Numbers of adults of *C. donowani* have been seen recently flying near plants of *Alocasia* at rain forest margins at Mount Warning and Terania Creek in north-eastern New South Wales but no larvae were found. I have previously (McAlpine, 1978) mentioned some other insects associated with *A. macrorrhizos*.

Other recorded food plants for *C. donowani* are *Cissus antarctica*, family Vitaceae (Scott, 1891, given as *Vitis antarctica*), *Boerhavia diffusa* (tah-vine), family Nyctaginaceae (Nicholas, 1935), and *Hibbertia*, family Dilleniaceae (Common, 1970: 866). It is interesting that the four recorded food plants, all of which are native to Australia, belong to different families which are widely separated systematically.

Scott (l.c.) has given an illustration and brief description of the larva.

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## SYNOPSIS OF LOCALITIES AND KEY TO THE PSOCOPTERA OF NORFOLK ISLAND

By C. N. Smithers

The Australian Museum, 6-8 College Street, Sydney, 2000

### Abstract

This paper provides a key to the sixteen species of Psocoptera known from Norfolk Island, a list of island localities from which each has been taken and notes on habitat preferences. The list is based on published records and recently collected material.

### Introduction

Smithers and Thornton (1974) recorded fifteen species of Psocoptera from Norfolk Island based on material collected between 1968 and 1972; Smithers (1980) added another. A recent collection by Dr G. Monteith has provided about 150 specimens (in the Queensland Museum) including all but three of the recorded species. Smithers and Thornton (*loc. cit.*) did not provide a key to the species but with the likelihood of increased research on the island it would seem appropriate to present such a key here and at the same time take the opportunity of providing a synopsis of island localities from which each species has been taken and provide what information is available on habitat preferences.

The synopsis includes published records and localities of the recently collected material.

### Key to adults of Norfolk Island Psocoptera

1.	Tarsi 3-segmented . . . . .	2
—	Tarsi 2-segmented . . . . .	7
2.	Fully winged, wings membranous with obvious venation, without scales . . . . .	3
—	Wings reduced, sometimes very short, elytriform, with indistinct venation scales present . . . . .	4
3.	Areola postica fused with M, i.e. Cu <sub>1a</sub> fused with M. Fore wing with dense, mottled pattern . . . . .	<i>Phlotodes australis</i>
—	Areola postica free, i.e. Cu <sub>1a</sub> not fused with M. Fore wing mostly hyaline . . . . .	<i>Haplophallus emmus</i>
4.	Frons without distinctive pattern, mostly of one colour . . . . .	5
—	Frons with distinctive pattern . . . . .	6
5.	Fore wings elongate, anterior and posterior margins parallel for most of their length . . . . .	<i>Lepolepis graemei</i>
—	Fore wings not elongate, strongly reduced, anterior and posterior margins not parallel . . . . .	<i>Pteroxanium ralstonae</i>
6.	Frons with a median pale line and one transverse pale bar . . . . .	<i>Pteroxanium evansi</i>
—	Frons with a median pale line and two transverse pale bars . . . . .	<i>Pteroxanium insularum</i>
7.	Brachypterous . . . . .	8
—	Macropterous . . . . .	9

8. Head dark brown in strong contrast to pale body. . . . . *Ectopsocus richardsi*  
 — Head and thorax both dark brown . . . . . *Peripsocus milleri*

9. Areola postica fused with M. . . . . *Blaste lignicola*  
 — Areola postica free or absent, i.e. Cu<sub>1a</sub> not fused with M or Cu<sub>1</sub> not branched . . . . . 10

10. Cu<sub>1</sub> branched, i.e. areola postica present, free. . . . . 11  
 — Cu<sub>1</sub> not branched, i.e. no areola postica. . . . . 13

11. Setae on veins of fore wing in two rows; areola postica long and shallow . . . . . *Heterocaecilius variabilis*  
 — Setae on veins of fore wing in single row; areola postica deep. . . . . 12

12. Cell IA darker than distal parts of wing membrane; fore wing length 3.0 - 3.2 mm . . . . . *Caecilius pacificus*  
 — Cell IA not appreciably darker than distal parts of wing membrane; fore wing length 1.8 - 2.0 mm. . . . . *Caecilius insulatus*

13. Claws with preapical tooth; hind wing with Rs and M fused for a length. . . . . 14  
 — Claws without preapical tooth; hind wing with Rs and M joined by a crossvein . . . . . 15

14. Fore wings hyaline with a small dark spot at nodulus and stigmapophysis and with R<sub>1</sub> at end of pterostigma dark. . . . . *Peripsocus norfolkensis*  
 — Fore wings with broad, pale brown band from basad of pterostigma to basad of nodulus; pale brown patch between Rs and M after separation; R<sub>1</sub> at end of pterostigma not darker than rest of vein . . . . . *Peripsocus milleri*

15. Male ninth tergite with two transverse rows of teeth. Female subgenital plate with two incurving posterior lobes. . . . . *Ectopsocus briggsi*  
 — Male ninth tergite with at most one row of teeth. Female subgenital plate with short, broadly triangular posterior lobes . . . . . 16

16. Pterostigma narrowest towards distal end, i.e. Rs curves gently towards costa. . . . . *Ectopsocus inornatus*  
 — Pterostigma widest at distal end, Rs curves abruptly to meet costa at right angle . . . . . *Ectopsocus insularis*

#### Synopsis of locality records for Norfolk Island

##### LEPIDOPSOCIDAE

*Pteroxanium ralstonae* Smithers and Thornton. On three trunks and leaf litter in rainforest. Loc.: Collin's Head, Burnt Pine, Mount Pitt Reserve.

*Pteroxanium evansi* Smithers and Thornton. On tree trunks and leaf litter in rainforest. Loc.: Bumbora, Rocky Point Reserve, Collin's Head, Selwyn Reserve, Point Blackbourne, Stockyard Creek, Mount Pitt Reserve.

*Pteroxanium insularum* Smithers and Thornton. On trees in rainforest. Loc.: Point Ross, Mount Pitt Reserve, Captain Cook Monument, Collin's Head, Jonneniggabunnit, Melanesian Mission, Burnt Pine, Palm Glen, Selwyn Pine Rd.

Point Blackbourne, Mission Rd., Cascade-Red Rd., Stockyard Creek, Rocky Point Reserve, Philip Island.

*Lepolepis graemei* Smithers and Thornton. Only found in leaf litter from a variety of plant associations. Loc.: Rocky Point Reserve, Palm Glen, Duncombe Bay, Burnt Pine, Mount Pitt Reserve, King Fern Gully, Steel's Point.

#### CAECILIIDAE

*Caecilius insulatus* Smithers and Thornton. On leaves from a variety of plant associations. Loc.: Captain Cook Monument, Selwyn Reserve, Rocky Point Reserve, Cascade-Red Rd., Bumbora, Point Blackbourne, Mission Rd.

*Caecilius pacificus* Smithers and Thornton. From broad leaved plants. Loc.: Selwyn Pine Rd., Captain Cook Monument, Rocky Point Reserve, Burnt Pine, Selwyn Reserve, Stockyard Creek, Collin's Head, Mount Bates, Ball Bay, Mount Pitt Reserve, Palm Glen, Bumbora, Point Ross, Melanesian Mission.

#### ECTOPSOCIDAE

*Ectopsocus briggsi* McLachlan. Beaten from dead leaves. Loc.: Ross Point, Rocky Point Reserve, Burnt Pine, Palm Glen, Melanesian Mission, Anson Bay, Mount Pitt Reserve, Captain Cook Monument, Mount Bates.

*Ectopsocus richardsi* (Pearman). From gut of gecko but known from stored products in several parts of the world.

*Ectopsocus insularis* Smithers and Thornton. From dead leaves. Loc.: Burnt Pine, Melanesian Mission, Bumbora, Anson Bay, Rocky Point Reserve.

*Ectopsocus inornatus* Smithers and Thornton. From dead leaves. Loc.: Mount Pitt Reserve, Palm Glen, Captain Cook Monument.

#### PERIPSOCIDAE

*Peripsocus milleri* (Tillyard). On twigs and stems. Loc.: Mount Pitt Reserve, Burnt Pine.

*Peripsocus norfolkensis* Smithers and Thornton. On twigs and stems from several plant associations. Loc.: Stockyard Creek, Point Ross, Burnt Pine, Melanesian Mission, Mount Pitt Reserve, Jonneniggabunnit, Collin's Head, Selwyn Pine Rd., Rocky Point Reserve, Captain Cook Monument, Mission Rd., Anson Bay Rd., Palm Glen.

#### PSEUDOCaeciliidae

*Heterocaecilius variabilis* Smithers and Thornton. Beaten from variety of plant associations. Loc.: Captain Cook Monument, Bumbora, Palm Glen, Burnt Pine, Mount Pitt Reserve, Rocky Point Reserve, Selwyn Pine Rd.

#### PHILOTARSIDAE

*Haplophallus emmus* Smithers and Thornton. Beaten from shrubs and trees. Loc.: Captain Cook Monument, Mount Pitt Reserve, Ross Point, Rocky Point Reserve.

#### PSOCIDAE

*Blaste lignicola* (Enderlein). From twigs and stems. Loc.: Ross Point, Melanesian Mission, Mount Pitt Reserve, Bumbora, Rocky Point Reserve, Palm Glen, Middlegate, Selwyn Pine Rd., Burnt Pine.

## MYOPSOCIDAE

*Phlotodes australis* (Brauer). On bark. Loc.: Point Blackbourne, Cascade, Burnt Pine.

## Notes on habitat preferences

**Lepidopsocidae.** The four species appear to be endemic to the island, all inhabiting the original rain forest plant association. *Pteroxanium ralstonae*, and *Pt. evansi* occur on tree trunks and in leaf litter; *Pt. insularum* has been taken only from the aerial parts of the plants whereas *Lepolepis graemei* appears to be mainly a leaf litter species.

**Caeciliidae.** Most species of *Caecilius* occur on the leaves of broad-leaved plants; the Norfolk Island species have been taken only from the aerial parts of the plants.

**Ectopsocidae.** Members of this family are mainly inhabitants of dried leaves. The Norfolk Island species have been taken from dead leaves and flower heads, except for *Ectopsocus richardsi* of which the only Norfolk Island specimen was found in the stomach of a gecko. This same species has a very wide distribution and has been taken from various stored products in several countries. Its native habitat is not known but it is probably an inhabitant of dried seed heads. The gecko is known to feed at flowers. *Ectopsocus briggsi* is known from many parts of the world but *E. insularis* and *E. inornatus* have so far been found only on Norfolk Island.

**Peripsocidae.** Most species are associated with twigs and stems of woody plants; the Norfolk Island species, of which only *Peripsocus norfolkensis* appears to be endemic, occur in similar habitats.

**Pseudocaeciliidae.** *Heterocaecilius variabilis* has been taken from aerial parts of plants in a variety of plant associations. It is probably a leaf dweller.

**Philotarsidae.** *Haplophallus emmus* is probably endemic, inhabiting twigs and stems of woody plants.

**Psocidae.** *Blaste lignicola* is found on twigs and branches; it is not endemic, occurring also in Australia.

**Myopsocidae.** *Phlotodes australis* is mainly an inhabitant of tree trunks and branches; it occurs in New Zealand and is widespread in Australia where it is common on weathered paling fences.

## Acknowledgement

I would like to thank Dr G. Monteith for the opportunity of studying his Norfolk Island Psocoptera collections.

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## NOTES ON THE LIFE HISTORY OF *CETHOSIA PENTHESILEA* *PAKSHA* FRUHSTORFER (LEPIDOPTERA: NYMPHALIDAE)

By M. C. Hall

33 Graham Street, Stuart Park, Darwin, N.T. 5790

### Abstract

The author briefly describes the life history of *Cethosia penthesilea paksha* Fruhstorfer including the first report of an Australian food plant.

### Introduction

The orange lacewing *Cethosia penthesilea paksha* Fruhstorfer is confined to patches of relict monsoon rain forest distributed throughout the northern part of the Northern Territory over an area north of latitude 15° S. Adults can be found throughout the year but are usually more common during the first half of the dry season (April to July).

### Life history

*Food plant.*— The food plant, *Adenia heterophylla* Blume (Koord) subspecies *australis* (Robert Brown ex deCondolle) deWilld. (Passifloraceae) is a rampant climber to 30 m in length reaching high into the tops of trees, and bearing bright green entire leaves up to 15 cm long x 10 cm wide. The plant bears conspicuous ovoid fruit, about 4 cm long, green at first then ripening to a rich crimson, which split to reveal passionfruit-like seeds.

On 30 May 1976, three first instar larvae were collected together with their food plant from an area of moderately timbered monsoon rain forest, situated adjacent to open black soil plains, 5 km east of the Adelaide River along the Arnhem highway.

*Larva* (Fig. 1).— The first instar larvae were bright reddish brown in colour, with a white horizontal band on abdominal segment 4, and a black head. All segments were clothed with bristles. Later instar and mature larvae were orange with brown intersegmental bands, abdominal segment 4 chalk white, and thoracic and abdominal segments 2, 6 and 8 with large chalk white lateral areas. The anterior half of the prothorax was also white above. The thoracic and abdominal segments each had six long tapering spines, black except on abdominal segment 4, where they were chalk white, tipped with black. The head was black with two long black cylindrical spines.



Fig. 1. Last instar larva of *Cethosia penthesilea paksha*.

The larvae were gregarious, feeding, moulting and pupating together. In captivity they preferred to eat the stems and fruit of the food plant rather than the leaves; indeed, woody stems up to 1 cm in diameter were completely devoured. Two larvae pupated on 24 June 1976.

*Pupa* (Fig. 2).— The pupae were bluish black in colour, mottled with white. They had a pair of knobbed anterior processes and a pair of short white dorsal spines on the head, three shiny gold dorsal spots on the thorax, six white spines up to 7.5 mm in length on abdominal segment 3, and paired flattened dorsal processes with sharp tips on abdominal segments 2 and 4 to 6, the largest on 2. The pupae were suspended by the cremaster.



Fig. 2. Pupa of *Cethosia penthesilea paksha*.

### Discussion

The spines on both head and body of *C. penthesilea paksha* are not branched. In other species of *Cethosia*, including *C. cydippe* L., the larvae are said to have branched spines (Common and Waterhouse, 1972; Corbet and Pendlebury, 1978), but at least in *C. cydippe* the branches are reduced to small spicules (Common, pers. comm.) and this could be true of exotic species also. The pupa is grotesquely shaped and bears some resemblance to that of *C. cydippe* (Common and Waterhouse, 1972, figs 17L, 17M), but there are prominent white spines in *C. penthesilea* and flattened, centrally expanded dorsal processes of the abdomen, with sharp points.

### Acknowledgements

I would like to thank Madelaine Rankin, Government Botanist, Berrimah Experimental Farm for identifying the food plant.

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## A PRELIMINARY NOTE ON THE PAPILIONOIDEA (LEPIDOPTERA) OF TUGLO WILDLIFE REFUGE, NEW SOUTH WALES

By C. N. Smithers

The Australian Museum, 6-8 College Street, Sydney, 2000

### Abstract

A total of 35 species of Papilionoidea (butterflies) is recorded from Tuglo Wildlife Refuge, situated about 10 km south-west of Mount Royal, New South Wales. Data on seasonal flight periods based on three year's observation are given and the local status of each species is tentatively indicated. Lycaenids are very poorly represented and satyrine species have been found to have very regular seasonal appearances.

### Introduction

Tuglo Wildlife Refuge is a privately owned property of 214 hectares, situated about 10 km south-west of Mount Royal and about 49 km north of Singleton, New South Wales ( $32^{\circ}14'S$   $151^{\circ}16'E$ ). It is located on a ridge forming an outlier of the Mount Royal Range with altitudes ranging from 760 m to 320 m. The Refuge is of some interest because of its intermediate position between Barrington Tops to the north and the low lying Hunter Valley to the south.

This paper is based on observations made on the butterflies (Papilionoidea) of the Refuge; the skippers (Hesperioidea) have not been included as observations on them are continuing.

### The environment

Apart from a relatively flat, higher altitude north-eastern area of about 24 hectares, most of the property consists of an irregular, steep-sided ridge running more or less east-west, descending in a series of ledges or platforms to the western boundary formed by Falbrook, a tributary of Glennie's Creek which, in turn, drains into the Hunter River. Steep-sided gullies run to the north-west and south from the ridge.

Little meteorological data is available for the area; the rainfall was in excess of 1300 mm in 1977 and 1840 mm were recorded in 1978. Winds are mainly from the north-west and the south-east, the former being responsible for the hotter, dryer conditions on the northern slopes in summer and the harsh conditions in winter; the south-east winds provide a cooler influence in summer. The effects of these winds is clearly seen in the varied vegetation pattern; the northern slopes support dry sclerophyll and the sheltered southern slopes support rain forest and wet sclerophyll. Summer temperatures are high, exceptionally as high as  $40^{\circ}C$ ; frost is frequent in winter and light snowfalls occasionally occur.

The major plant communities include rain forest, wet sclerophyll, eucalyptus woodland, dry sclerophyll and grassland; there is a small cultivated

horticultural area. The boundaries between the main vegetation types are remarkably sharp in most cases.

### Methods

Between 28th August, 1976 and 16th April, 1979, 105 visits were made to the area; most visits were of two days (weekends) but several were of much longer duration (up to a fortnight). On each visit a record was kept of the butterflies in flight. A small reference collection is housed at the Refuge and will eventually be incorporated into the Australian Museum collections.

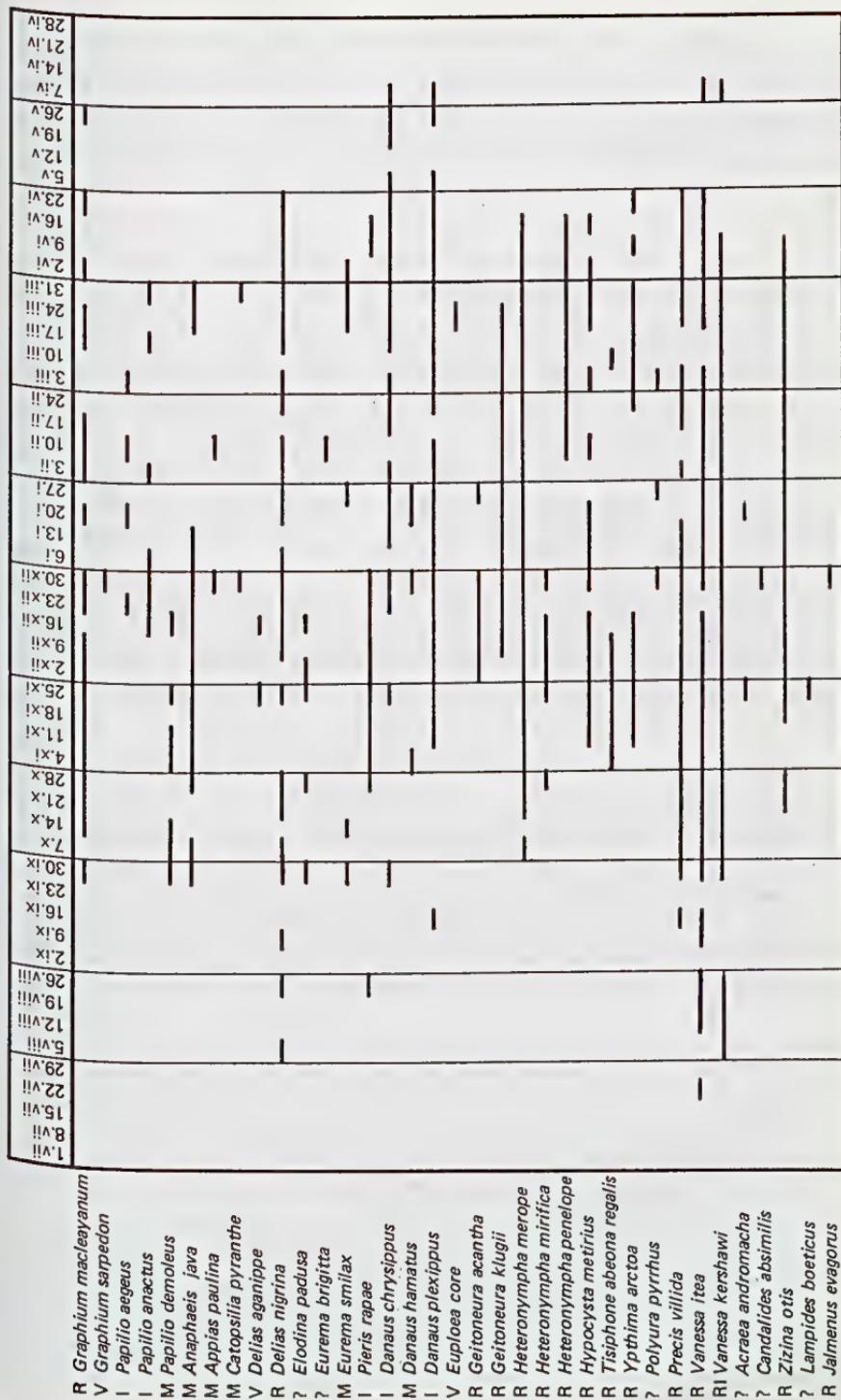
For this paper the data has been summarized on a seven day basis by dividing the year into seven day periods and combining the records for each equivalent period each year. For example, species observed between the 2nd and 8th December inclusive are recorded for that period irrespective of the year or number of observations. The first period is arbitrarily taken as 1st-7th July. In this system leap years are ignored so that the period 24th February to 2nd March has an extra day in leap years. The single day remaining (365th) after dividing a year into seven day periods is always included in the period 23rd-30th June. By summarizing records in this way those for one year reinforce those for another to provide broad seasonal patterns. This gives a more refined picture than records presented on a monthly basis. Although possible, it is less practical to refine the system to daily records and doing so would confer little advantage here over summary by seven day periods. Data are, however, originally recorded on a daily basis and are available at that level if required. In the present series of 105 visits there is only one seven day period during which observations were not made, i.e. 12-18th May.

### Results

Thirty five species of Papilioidea have been recorded from the Refuge. The number recorded in flight in each seven day period is given in Fig. 1. The highest number for any one period is 23 (early January) and there is virtually no flight activity through most of June and July. Prior to the end of September few species are flying and the number drops during the latter part of April and during May. Activity increases during October and November to reach its peak from late November to early January, with an indication of a lesser peak of activity in late March and early April apparently due to adult emergence in those species which have two distinct generations annually.

Observations made so far are insufficient to establish the status of each species for the area; tentative conclusions are indicated as follows:—resident species (R) with some stage present at all times of year; vagrant species (V) of which an occasional specimen enters the area; migratory species (M) of which populations enter the area on a regular seasonal basis but do not breed and intinerant species (I) of which specimens arrive on a regular seasonal basis and breed, but the species is not present at all times of the year; this implies that the populations leave after breeding. The tentative nature of this status determination must be stressed as little observation other than on adult occurrences has so far been made.

Fig. 1. Species flying in each seven day period.



The species recorded in flight in each period are given in Fig. 2. All except three species (91% of the total recorded) had made their appearance by the first week in January. Of these, two were probably vagrants (*Euploea core* and *Eurema brigitta*); only the third (*Heteronympha penelope*), which appears in mid February, can be considered a resident of the area.

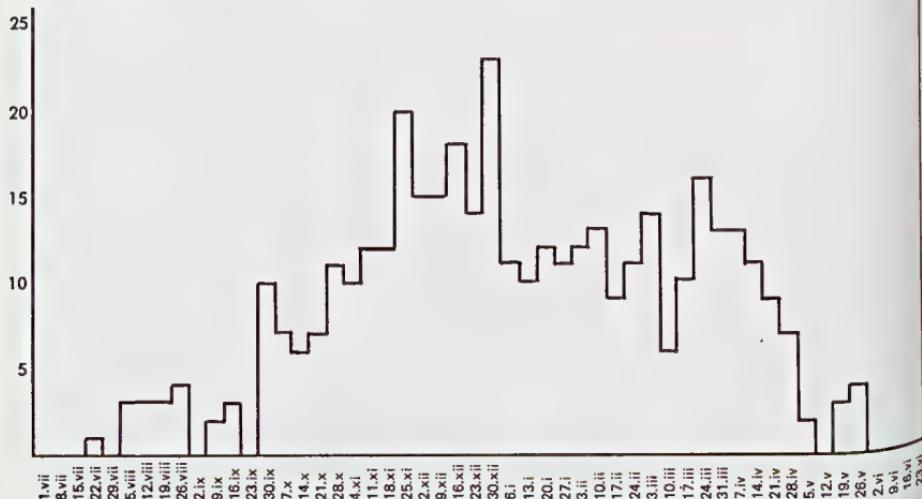


Fig. 2. Number of species in flight in each seven day period.

#### PAPILIONIDAE

*Graphium macleayanum* (Leach) flies from October to May and is probably present throughout the year whereas *G. sarpedon* (L.) is a casual visitor (only one sighting). *Papilio aegeus* Don. and *P. anactus* Macl. are not common and their relatively late appearance, in December, suggests that they move into the area from elsewhere; if pupae are overwintering in the area an earlier appearance would be expected. *P. demoleus* (L.) has been seen only as occasional individuals, usually flying very fast to the N or NE; a NE migration was noted on 13-14th November, 1976 involving many specimens.

#### PIERIDAE

*Anaphaeis java* (Spar.) appears at two distinct periods: it is a migrant and is usually clearly moving through the area; only occasionally have specimens been seen to remain in a restricted area for any length of time. *Appias paulina* Cram., *Catopsilia pyranthe* (L.) and *Delias aganippe* (Don.) have each been seen on only two occasions. *Delias nigrina* (F.), on the other hand, is clearly resident and one of the earliest species in flight. *Elodina padusa* (Hew.) is not common and has not been seen later than the end of December; its status is uncertain. *Eurema brigitta* Cram. has been seen only once, in February, but *E. smilax* (Don.) appears to have two distinct periods of occurrence, one early in the season and the second as late as April. *Pieris rapae* (L.), likewise, is commonly present from November to December but after that has not been recorded until April. The only certain all year round resident pierid is *D. nigrina*.

## NYMPHALIDAE - DANAINAE

Both *Danaus plexippus* (L.) and *D. chrysippus* (L.) are absent during winter, neither being common until November although occasional specimens may occur earlier. Incoming adults establish breeding populations on *Gomphocarpus fruticosus* L. but there is little evidence of either species after mid June. *D. hamatus* (Macl.) is an occasional visitor and *Euploea core* (Cram.) has been seen only once.

## NYMPHALIDAE - SATYRINAE

Most species of this subfamily occur at fairly high population levels and there is a distinct and remarkably regular sequence of appearance of species although *Tisiphone abeona regalis* Wat. occurs in low numbers over very restricted areas. *Heteronympha merope* (F.) is the first to appear in October and is present until late April. The females are much less evident than the males early in the season but can be found in large numbers sheltering under banks, near logs or in other shady situations until after the number of males has declined in mid January. Female flight activity is especially conspicuous from mid February until late March with a few specimens seen as late as mid to late April.

In early and mid January females are frequently seen settling briefly on water, such as dams and deep pools in rivers, and taking off again. This habit appears mainly to coincide with the break up of the groups which have been occupying sheltered positions during the hotter periods of summer. Small numbers of *H. mirifica* (But.) are in flight from November but this species has disappeared by early January. *Hypocysta metirius* But., *Tisiphone abeona regalis* and *Ypthima arctoa* (F.) all appear at about the same time in mid November, the two last-mentioned disappearing by mid December but reappearing again in early March. *T. abeona*, however, appears to be in flight for a very short period whereas *Y. arctoa* may continue into May. *Geitoneura acantha* (Don.) appears in early December and is obvious for only a short period, until the end of January at the latest; shortly after its appearance, i.e. in mid December, *G. klugii* (Guer.-Men.) appears and remains in flight until the end of April. Finally, *H. penelope* Wat., the latest satyrine species, does not appear until early February and is in flight until the end of April. The Satyrinae are remarkable for the regularity of their appearance, each species appeared within a day or two of the same date in each of the three years covered by the present observations.

## NYMPHALIDAE - CHARAXINAE

Only a few specimens of *Polyura pyrrhus* (L.) have been seen, mostly in January.

## NYMPHALIDAE - NYMPHALINAE

*Precis villida* (God.), *Vanessa kershawi* (McCoy) and *V. itea* (F.) are sometimes very common, especially the two *Vanessa* species. They are the earliest species to appear in numbers and can be seen in flight until the end of April. Only *D. plexippus* and *D. chrysippus* occur in any numbers later than the *Vanessa* species.

## NYMPHALIDAE - ACRAEINAE

*Acraea andromacha* (F.) has been seen on only a few occasions.

## LYCAENIDAE

The low number of lycaenid species recorded so far is remarkable. The only common species is *Zizina otis* (F.) which appears in numbers in November and has been seen as late as June although the major part of the population has disappeared by mid to late April. At times vast populations occur in pastures and open eucalypt forests, wherever clover is abundant. *Candalides absimilis* (Feld.), *Lampides boeticus* (L.) and *Jalmenus evagoras* (Don.) have been uncommon during the years of observations.

## Discussion

It is interesting to compare the results of the observations at Tuglo with the records for the Australian Capital Territory accumulated by Kitching *et al.* (1978). Considering the great differences in area involved the faunas are surprisingly similar, except for the lycaenids.

The papilionid faunas are identical in both localities.

The pierids are very similar except that Tuglo has *Appias paulina* (occasionally) and *E. brigitta* (occasionally) whereas A.C.T. has *Delias harpalyce* (Don.) and *D. argenthona* (F.) (occasionally). *Anaphaeis java* appears a little earlier in A.C.T.; there is a second, short April appearance, as at Tuglo.

The nymphalines are similar in the two areas but the danaines, *D. plexippus* and *D. chrysippus*, fly until much later at Tuglo and *D. plexippus* does not appear until much later than *D. chrysippus* in A.C.T. The satyrines differ considerably with many more species in A.C.T. This is due to the presence of the higher altitude species (above about 1200 m) and the "local" species *Heteronympha paradelpha*. The altitudinal differences are emphasized by the presence on Tuglo of a few "lower altitude" species, such as *Ypthima arctos* and *Hypocysta metirius* which are not recorded by Kitching *et al.* (1978). *H. merope* seems to appear earlier and *H. penelope* later at Tuglo than in A.C.T. so that the two species coincide in flight for a greater period there but with *H. merope* being in evidence for a shorter period than at Tuglo. The remaining nymphalids are similar in the two areas but in general show a slightly longer flight period at Tuglo.

The outstanding difference in the faunas is seen in the lycaenids in which there is an abundance of species (25) in A.C.T. but only four so far recorded at Tuglo, of which only one is common. This can be seen as a direct outcome of lack of host plants at Tuglo (even *Acacia* species being uncommon) and the lack of high altitudes.

## Acknowledgements

I would like to thank my wife Aletta and sons, Graeme and Hartley, for assistance in accumulating records on which this note is based.

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## REDESCRIPTION OF *HEMEROBIUS AUSTRALIS* WALKER (NEUROPTERA, HEMEROBIIDAE)

By T. R. New

Dept. Zoology, La Trobe University, Bundoora, Vic. 3083.

### Abstract

Both sexes of *Hemerobius australis* Walker are redescribed and figured. The genus *Hemerobius* is confirmed from Australia, and *H. australis* belongs to a southern hemisphere species group of this genus.

### Introduction

The genus *Hemerobius* L. has not been confirmed from Australia since Walker (1853) described *Hemerobius australis*, and later workers have doubted the generic placement of that species. Thus, Tillyard (1916) did not include *Hemerobius* in his key to Australian hemerobiid genera and, to judge from a footnote in his paper (1916: 307), considered that '*H. australis*' could be an aberrant specimen of the abundant *Micromus tasmaniae* (Walker), although noting the fore wing venational differences implied in the original descriptions. Likewise, Tjeder (1961) commented that *Hemerobius* is absent from Australia. A further source of doubt has been the data included in the original description, namely 'New Holland: presented by the Entomological Club'. The insects presented at that time are from various parts of the world, including North America, and there are places named 'New Holland' in both Illinois and Pennsylvania. There is thus the possibility of an error in label interpretation, as occurred with a similarly-labelled species of *Chauliodes* (Megaloptera) (McLachlan 1867).

The type of *H. australis*, however, is clearly labelled 'Australia', and does not convincingly resemble any described North American *Hemerobius* species. It is in poor condition and lacks antennae, legs except the fore femora, hind wings and abdomen; much of the remaining body is dirty and covered with gum. During a recent visit to the British Museum (Natural History) four Queensland specimens of a *Hemerobius* were found in unsorted material from the Tillyard collection, and these are clearly referable to *H. australis*. The following augmented description, which confirms the presence of *Hemerobius* in Australia, is based on these examples.

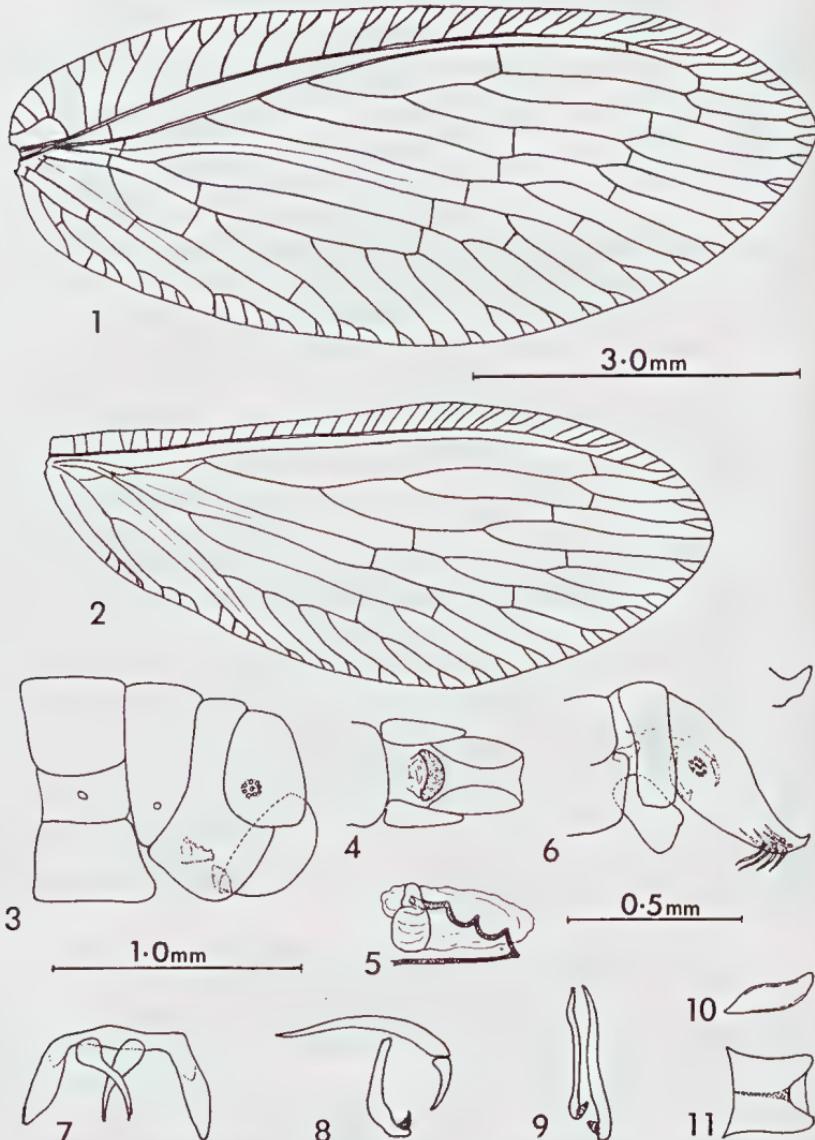
### *Hemerobius australis* Walker 1853: 289

(Figs 1-11)

**Coloration** (dry). Pale buff. Eyes dark grey. Genae dark brown. Sides of pronotum dark brown. Legs pale, except extremities of all tibiae slightly darkened. Fore wing pale, pterostigma not darkened; all branches of Rs and more posterior longitudinal veins with alternating dark and pale lengths (relative lengths about 1: 2), each dark length with traces of pale greyish brown sagittate shading on adjacent membrane. Gradates dark brown or grey, slightly shaded; membrane greyed behind  $Cu_2$ . Hind wing slightly fumose, unmarked, venation pale greyish brown. Abdomen buff.

**Morphology.** Fore wing length ca 7 mm, venation as in Fig. 1. Hind wing venation as in Fig. 2. All tibiae swollen, the hind tibiae markedly so.

FEMALE: Abdominal apex as in Fig. 3; ectoproct with field of 9 small trichobothria; gonapophyses laterales broadly rounded. Subgenitale (Fig. 4) arcuate, transverse and well-developed; margin of sternite VII transverse. Spermatheca (Fig. 5) small, membranous but with duct well-sclerotised.



Figs 1-11. *Hemerobius australis* Walker. (1, 2) wing venation: (1) fore wing; (2) hind wing; (3-5) ♀ genitalia: (3) apex of abdomen, lateral aspect; (4) apex of abdomen, ventral aspect to show subgenitale (shaded); (5) spermatheca; (6-11) ♂ genitalia: (6) apex of abdomen, lateral aspect with insert of apex of anoprocessus; (7) gonarcus and arcessus, posterior aspect; (8) genitalia, lateral aspect; (9) parameres, posterior aspect; (10, 11) hypandrium internum, lateral and ventral aspects. (Trichosors omitted from venation figures.)

MALE: Abdominal apex as in Fig. 6; ectoproct elongate, cataprocessus absent, anoprocessus small and tapered dorsally; a field of 10 small trichothchia; a group of about 8 thickened setae on inner margin near apex. Gonarcus (Figs 7, 8) with strongly reflexed lateral arms; arcessus (Figs 7, 8) relatively short, represented by two ventrally directed sinuous tapered rods. Parameres (Figs 8, 9) slender, sinuous and not strongly divergent, with slight hook at ventral edge. Hypandrium internum (Figs 10, 11) short, with ventral median keel, apex slightly emarginate.

*Material examined.* Holotype, sex indeterminate, 'Australia, Ent. Club. 44-12'; 1 ♂, Queensland, Ingham, 13.vi.30; 2 ♀♀, 1 sex indet., Queensland, Mt. Gibbs, 20.iv.30; all in British Museum (Natural History), London.

### Comments

*H. australis* belongs to a small southern hemisphere group of *Hemerobius* which lack a cataprocessus on the male ectoproct. It is thus similar to several species from southern Africa (Tjeder 1961), mainland Chile and Argentina (Nakahara 1960, 1965) and Robinson Crusoe Island (Handschin 1955). This species group is now known from the major regions of the southern hemisphere and appears very distinct from the numerous northern species of *Hemerobius*.

*H. australis* is most similar to *H. rudebecki* Tjeder, *H. abditus* Tjeder and *H. chilensis* Nakahara, but differs from all on details of genitalia. The anoprocessus of *australis* is more pronounced than in any of these species, which all lack the group of thickened setae on the male ectoproct. This condition is reminiscent of some species of *Wesmaelius* [represented in Australia by *W. subnebulosus* (Stephens)] by lacking a fore wing crossvein between M and the base of the first branch of Rs. It is separable from *Micromus* Rambur (the genus containing the most abundant and widely-distributed Australian hemerobiids) by the form of the fore wing radial sector and the presence of a recurrent humeral vein. In *Micromus*, the fore wing Rs has four to six branches from its stem. In *Hemerobius* there are only three branches, with the distal dividing into three as in Fig. 1.

### Acknowledgements

I am very grateful to Dr P. Freeman (Keeper of Entomology) and to Dr P. C. Barnard for allowing me to study Neuroptera in the British Museum (Natural History).

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produce strong smelling or corrosive chemicals and a few of the former family, notably the bombardier beetles, discharge a hot, explosive mixture when disturbed. These are the pinnacle of evolution in beetle chemical defence.

### Natural enemies and hazards

Beetles like all small, rapidly reproducing forms of life, are subject to large losses at all stages of their development. The eggs are parasitised by small chalcid wasps, or eaten by mites and other scavengers, and the larvae and pupae are preyed upon by centipedes, wasps and other beetles (sometimes by adults of their own species), as well as vertebrates of various groups. Birds such as magpies destroy large numbers of ground-dwelling curl grubs and the larger cockatoos rip cerambycid and other timber borers from their burrows. Many larvae are parasitised by wasps or two-winged flies before completing their metamorphosis; others succumb to specific fungi or to bacterial or viral diseases.

Adult beetles form an important element in the diet of most insectivorous amphibians\*, reptiles, birds and mammals and aquatic beetles are also preyed upon by fish. Centipedes and spiders (especially the notorious Redback) take their toll of the ground dwellers and the large huntsman spiders are deadly enemies of those living under bark. Flycatchers and other birds catch the day-fliers and bats consume many of the nocturnal forms.

Huge losses are frequently incurred through climatic disasters which, in Australia, include drought, fires, floods and sudden drops in temperature associated with southerly wind changes. The last mentioned hazard, which is highly characteristic of the local climate, leads to frequent stranding of myriads of flying beetles and other insects in unfavourable surroundings, sometimes far out to sea.

Probably the greatest single threat to our more fastidious native beetles comes, however, from destruction of their preferred habitats through the activities of man. Many of the more attractive species in south-eastern Australia are now evidently much scarcer and more restricted than in the days of pre-war coleopterists, as described by H. J. Carter in his still informative "Gulliver in the Bush" (1933). The justly famous Sydney sandstone formerly one of the richest areas for blossom insects in the whole country, has now receded drastically in face of the accelerating urban sprawl and many other one-time interesting tracts of native bush, well removed from the big cities, have become depauperate through the effects of clearing and intensive grazing. Mountain forests are fortunately more secure and although more frequently burnt over than in the early days, they remain one of the chief reservoirs of our diminishing fauna.

\* The introduced Cane Toad causes huge losses in Queensland. It now also occurs in north-eastern New South Wales.

## CLASSIFICATION AND NOMENCLATURE

Although we may gain a great deal of pleasure from observing animals in the field, without ever putting a name to them, the matter of identification becomes important as soon as we wish to communicate our findings or to draw from the fund of information accumulated by others. Early man quickly discovered this need and he soon coined terms for bears, wolves, snakes and other familiar groups that were important in his environment. But the system of common names inevitably showed its limitations later, when something of the real diversity of nature became apparent: the realisation that there were several kinds of bear, for instance, required binomial expressions such as 'brown bear', 'grizzly bear', 'polar bear', etc. Then with further increase in knowledge, it would have been necessary to distinguish the 'European brown bear' from its American counterpart, and so on. Here, already, were the beginnings of a classification. However, common names were becoming cumbersome and were quite unable to cope with the increasingly large numbers of species being discovered, particularly in such diverse groups as beetles, which concern us here. Moreover, such names had the additional drawback that they often varied (and in fact still do) in usage from place to place. Early pioneers of far-away places tended to name the local animals after those they knew at home, often with unfortunate results. Thus the term 'badger' now denotes different though related animals in Europe and America, and the Australian 'magpie' does not belong even to the same family as its European namesake. On a more local note, our common term 'Christmas beetle' denotes something different in every State. One could quote many similar examples.

Fortunately indeed, the eminent Swedish, eighteenth-century biologist, Carl von Linné (whose name is usually rendered in its latinised form Carolus Linnaeus) foresaw the chaos that would result from the continued and undisciplined expansion of the numerous naming systems then in use, and he proposed an alternative and potentially international scheme, based upon Latin names of standardised form. Linnaeus published his *Systema Naturae* at a time when only a small fraction of the world's plant and animal species were known and when all forms of life were believed to be immutable. Yet his work was able to weather the complete upheaval in biology caused by Darwin's epoch-making theory of evolution and has continued to accommodate the vast numbers of new organisms that have been discovered in the intervening two hundred years. Today, the tenth edition of the *Systema Naturae*, published in 1758, is still regarded as the official starting-point of zoological nomenclature.

Linnaeus divided the world of nature into three kingdoms, the animal, the vegetable and the mineral, but only the first of these concerns us here. Within the animal kingdom, he recognised and defined by means of common characters, six major groups, termed 'classes', namely, Mammalia (mammals),

Aves (birds), Amphibia (frogs, toads, etc.), Pisces (fish), Insecta (insects, etc) and Vermes (worms). These Classes are still accepted today, although the scope of some has needed to be restricted. Linnaeus divided his Classes into Orders which, in the Class Insecta, comprised: Coleoptera (beetles), Hemiptera (sucking bugs), Lepidoptera (butterflies and moths), Neuroptera (lace-wings, etc.), Hymenoptera (ants, wasps and bees), Diptera (two-winged flies) and Aptera (fleas, spiders, crabs, scorpions, etc.). The Aptera was something of a dumping ground for various jointed animals, most of which we no longer associate with insects but the other Orders are still retained as valid today. Within his Orders, Linnaeus recognised groups of related species which he called 'genera' (singular: genus) and he gave each of them an unique Latin substantive name. Species within a genus were given a distinctive (usually descriptive) Latin name also, so that the combination genus species names not only provided a unique citation for each organism but also included an indication of relationship as well. Thus in the Mammalia, *Felis catus* denoted the domestic cat, *Felis leo* the lion, *Felis tigris* the tiger, and so on. The domestic dog (*Canis familiaris*) shared a genus with the wolf (*C. lupus*), the fox (*C. vulpes*), the hyaena (*C. hyaena*), etc., which we still regard as being more or less closely related, although not all are retained in the one genus today.

Although Linnaeus dealt with only a few thousand species, these already formed too large and diverse a group for one man to understand fully, so it is hardly surprising that he made a few mistakes. For example, he included the cockroaches, as a genus *Blatta*, in the Coleoptera and although the layman might still make the same mistake today, biologists are agreed that cockroaches are not beetles but belong to a much more primitive group that merits the status of a separate Order, the Blattodea. Likewise, the tremendous increase in species known to science has required great expansion of the Linnean system, both at the lower levels of genus, species, etc., and in the range of higher categories employed. Since we are concerned here only with the Order Coleoptera, some of the new higher categories need not be set out but the following example, showing the systematic position of the South Coast Tiger Beetle, will demonstrate the method:—

CLASS:	INSECTA	
ORDER:	COLEOPTERA	(beetles)
SUBORDER:	ADEPHAGA	(predaceous beetles)
Superfamily:	<u>Caraboidea</u>	
Family:	<u>Carabidae</u>	(Ground beetles)
Subfamily:	<u>Cicindelinae</u>	(Tiger beetles)
Tribe:	<u>Cicindelini</u>	
Genus:	<u>Cicindela</u>	
Species:	<u>ypsilon</u>	

It should be noted that the names of the four higher categories above the genus are formed by adding standard Latin endings to the grammatical 'stem' of an included genus name: Tribe = stem + INI; Subfamily = stem + INAE; Family = stem + IDAE; Superfamily = stem + OIDEA. The existence of these standard endings enables one to recognise the status of any new or unfamiliar name at sight. Generic names are spelled with an initial capital letter but specific names should always be rendered entirely in lower case\*, even when derived from a person's name; in print, both generic and specific names are set in *italic* script (e.g. *Notonomus carteri* Sloane). When citing an individual genus in isolation, it is sometimes necessary to give the original author's (describer's) name in full, e.g. *Cicindela* Linnaeus, but on subsequent mention in the same context, the latter may be abbreviated or omitted altogether. Likewise, the first full citation of a species should include the specific author's (but not the generic author's) name: *Cicindela ypsilon* Dejean, which may subsequently be abbreviated to *C. ypsilon* Dej. (Dejean was a nineteenth-century French coleopterist). Reference to more than one species within a genus would normally be given in the form: *Cicindela ypsilon* Dejean and *C. mastersi* Macleay, which implies that only one genus is involved. However, abbreviations are to be avoided when the possibility of ambiguity exists: *Cicindela ypsilon* Dejean and *Calosoma schayeri* Erichson (not *C. schayeri*). In formal nomenclatorial works and checklists, it is customary to place the author's name in parentheses if his species is no longer placed in the genus in which he described it.

The niceties of Latin grammar and other complexities of modern zoological nomenclature form a expertise in themselves and need not be considered in detail here. Suffice it is to mention that an international body† has drawn up a long list of rules governing the application of old names and the coining of new ones and these are generally accepted as binding by all those involved in this activity, the aim being of course to achieve complete international stability in the naming of all animals. Unfortunately however, we have by no means reached this utopian state of affairs; there is still a large backlog of old, incorrectly formed names that were bestowed before the rules became universally accepted and authors still discover (and sometimes create) synonyms that result from redescription, in ignorance, of animals already known in existing literature. Scientific names certainly do still change as any keen gardener, for example, will be fully aware, but they are nevertheless more reliable and meaningful than a host of common names could ever be. And they are generally not difficult to remember, when one makes the effort, although some beginners tend to be deterred by them. After all, many such as *Eucalyptus*, *Banksia* and *Rhododendron* have already passed into everyday language. Anyone with a knowledge of the classics will not be troubled in the slightest but will soon observe that many biological names are not genuine

\* Notwithstanding the practice of some Continental authors.

† The International Commission on Zoological Nomenclature.

Latin words but are merely given Latin form. Many generic (and some specific) names are derived from ancient Greek roots, e.g. *Phoracantha* (a genus of Longhorn beetles, Cerambycidae), from *Phorein* plus *acanthos*, meaning 'carrying a spine'; others may be merely anagrams (e.g. my carabid genera *Trephisa*, *Theprisa* and *Raphetis*, anagrams of the earlier *Teraphis* Castelnau) or even arbitrary combinations of letters. However, such names are always treated as if they were Latin substantives. Specific names are usually Latin adjectives, e.g. *albus* (white), *albomaculatus* (white-marked), *grandis* (large), that should agree in gender with the generic name. However modern specific names are often based upon other modern names and merely given a Latin-like form, e.g. *carteri*, named after H. J. Carter, a pre-war Australian coleopterist or *sydneyensis*, implying 'occurring in the Sydney region'. Some specific names are Latin (or Latin-like) nouns in apposition which unlike adjectival names, do not change their gender to suit a change of genus. Thus the small carabid *Stenolophus smaragdulus* Fabricius is now known as *Egadroma smaragdula* but *Stenolophus dingo* Castelnau becomes *Egadroma dingo* (named after the Australian dingo).

The various steps involved in classifying organisms, the description of new species, the coining of new names, the erection of new categories, the rearrangement of existing groups and so on, are collectively referred to as 'taxonomy' (after the Greek *tassos*, to arrange); the entities themselves (families, genera, species etc.) are called 'taxa' (singular: taxon); and the specialist dealing with them is a 'taxonomist'. Most naturalists would not wish to claim such status, when their interest lies mainly with well known groups (plants, mammals, birds, etc.). However, with so large and incompletely studied a group as the beetles, where identifications on sight are seldom possible, an elementary knowledge of the taxonomy is an essential basis for any serious work.

## MAKING A COLLECTION

Although many general naturalists will be content to observe living beetles in the field, those interested in publishing their findings will soon deem it necessary to preserve some specimens, as an important aid to identification, and the formation of an extensive reference collection is the logical next step (indeed a vital one) for anyone wishing to undertake serious and independent study of any section of our native Coleoptera. Such students will soon develop equipment and techniques to suit their own requirements and the following notes are therefore intended merely to provide a starting-point from which they may then make their own way. Further hints and directions of a more general kind may be obtained from "The Collection and Preservation of Insects" by K. R. Norris and M. S. Upton, 1974 (The Australian Entomological Society, Miscellaneous Publication No. 3).

### Field equipment

The requirements for field work with beetles are not great and equipment need not be expensive but it should be of strong and serviceable construction. Most of the smaller items that are constantly needed at hand are best carried in a satchel, slung over the shoulder and strapped or tied around the waist. The bag should be fitted with compartments of assorted sizes to allow for ready stowage and retrieval of tubes, boxes, killing bottles and instruments that are often needed in quick succession, with the minimum of fuss.

#### Nets

A lightly built aerial net of the type favoured by butterfly collectors will have limited use in beetle work but it will certainly be needed for catching the agile Tiger beetles (Carabidae, Cicindelinae), the larger Jewel beetles (Buprestidae) and others that take to the wing so readily in hot sunny conditions. A wide variety of nets is available from suppliers but the kinds with a folding, spring-steel hoop, a light-weight aluminium handle and a white nylon-mesh bag are the most suited to our purpose (beetles are often difficult to see in the black net bags favoured by lepidopterists). A second, short-handled net, triangular in cross-section, will also prove useful for under-bark collecting from living trees. The loop of such a net should have one side of taut string or cord so that, when pressed against the tree, it will take up the shape of the trunk.

The sweep net, used for brushing specimens from low herbage, and the water net may be of similar stout construction; both are liable to suffer a good deal of heavy wear. The hoop should be firm in use but preferably hinged for folding and the bag should be attached by means of a dozen or so brass rings (a direct cloth to hoop connection would soon become quite unserviceable through wear and tear).

### Specimen tubes

An assortment of stoppered glass specimen tubes will be needed to transport live beetles, particularly the larger species, and also larvae and pupae. The 75 mm x 25 mm size is probably the most useful and at least six should be carried, preferably in a suitable metal box. Plastic tubes of similar size might appear to be attractive alternatives and they are certainly lighter and less easily broken but they soon become scratched and semi-opaque and are attacked by some organic solvents and killing agents. A second box of smaller tubes is also useful.

### Aspirator

An aspirator or 'pooter' is indispensable for collecting small, easily damaged or active specimens from difficult situations, such as crevices in bark, amongst gravel or on wet mud, etc. This instrument (Fig. 24) may be made at home if a small quantity of glass tubing is available. A 75 mm x 25 mm glass specimen tube will serve well as the collection chamber and, of course, may quickly be replaced. In action, the mouthpiece is held between the teeth and the intake tube lowered over the specimen. A short, sharp

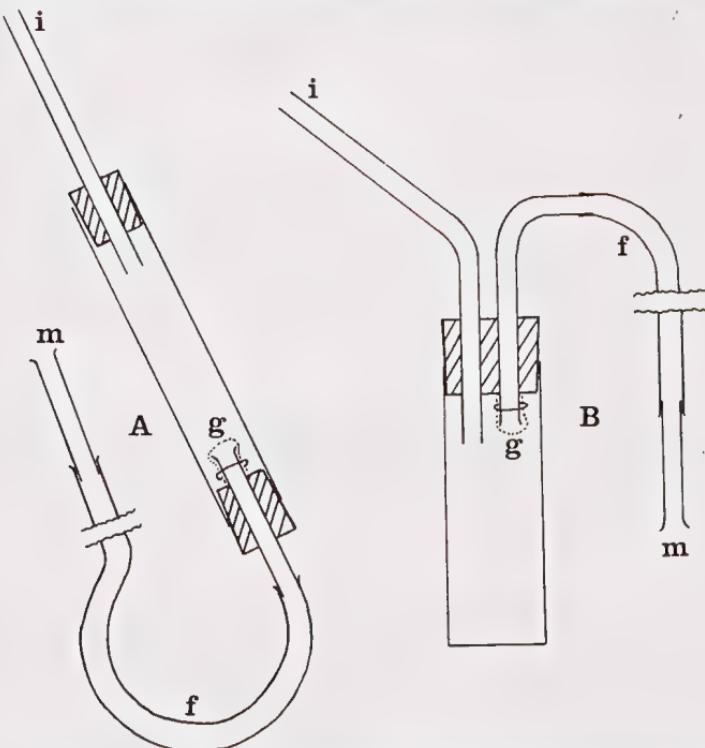


Fig. 24. Two kinds of aspirator (or 'pooter') for collecting small specimens. Model A is easier to construct but B has the advantage of taking replaceable standard vials. f, flexible rubber or plastic tube; g, gauze cover to prevent egress of specimens and detritus; i, rigid glass or plastic intake tube; m, rigid mouthpiece.

intake of breath will result in speedy transfer of the specimen to the collection chamber without fuss or damage. When sufficient specimens are present, the tube may be detached and stoppered or the contents emptied directly into the killing bottle (a wiser alternative when carnivorous species are present).

#### *Killing bottle*

Killing bottles may be of various shapes but need not be very large; my own, which has been in service for thirty years, is a 'four-ounce' (about 100 ml), wide-mouth, reagent bottle of a rather old-fashioned and solid (but eminently suitable) type, closed by a shallow cork bung. The surface of the bung has been sanded smooth and its rim rounded off to decrease the danger of accidental removal; its centre is pierced by an 18 mm hole, which is closed by a second and much smaller bung (I use a plastic stopper nowadays). Some collectors fit the inner hole with a short length of wide-bore glass tubing and stopper, a system that certainly renders escape more difficult. In use, the bottle is half-filled with crumpled paper tissue, to which has been added a small wad soaked in the killing agent (usually ethyl acetate). All but the largest captures are added through the smaller aperture, thus minimising loss of toxic vapours during repeated opening.

A couple of glass killing tubes, modelled on the same lines, are desirable as a reserve, or for segregating captures according to locality, habitat, etc., when one is on an extended trip.

#### *Probe*

A probing tool, such as a stout screw-driver or a blunt chisel, will also be needed; this can be used in a variety of ways, such as bark-scraping, breaking up rotten wood, raking wet gravel, turning dung-pads and so on. Forceps should also be carried but as they are so readily mislaid in the bush, they are best tied to the satchel by a generous length of string.

#### *Polythene bags*

Polythene bags of various sizes take up little room when empty and form ideal containers for fungi, twigs, leaf litter and other materials that may be required for detailed examination later, or for breeding purposes. Also a square of white plastic will serve as a shaking-sheet for examining earth or litter siftings in the open.

#### *Sieves*

Among more cumbersome items of equipment that will be needed less frequently we have the sieves, the beating tray and the light-trap. A nesting pair of sieves of 6 mm and 3 mm gauges, in light-weight aluminium of the type sold to gem collectors, suits our purpose well.

#### *Beating tray*

One type of beating tray is now available on the local market and others are obtainable overseas. Basically, they take the form of a sheet of

tough fabric (scrim or canvas) of about one metre square, supported on a collapsable frame and provided with a short, stout handle. Several designs are available and details of two are given by M. S. Moulds in the *Australian Entomological Magazine*, 1972, 1: 7-10. My own (which I constructed myself) opens and folds after the manner of a Japanese fan.

#### *Light sheets/traps*

The light for home use need be no more than a high-powered globe in a standard socket, with a long extension lead, and suspended over a white sheet, part of which should be hung vertically. Since beetles, like most insects, are more sensitive to the violet end of the spectrum, a globe that emits strongly in this region is best. A 'blended' mercury vapour globe is the most convenient choice, for it combines a fairly good spectral range with a long service life and runs directly from the mains. Mercury vapour lamps that require a heavy choke in the circuit are much more effective but less convenient. Low-wattage, portable fluorescent units with built-in circuitry, suited to running directly from a standard car battery, are now available from dealers and are ideal for night work in out-of-the-way places. "Black light" or "actinic blue" tubes can be fitted to these units and they greatly increase the catch, but the insects are difficult to see without a subsidiary lamp, and the wearing of protective goggles or sun-glasses is mandatory, to shield the eyes from damaging ultraviolet rays.

Traps that include a container beneath the globe are available commercially; these are safer when "black light" is to be used, since continuous monitoring is not required. However, they catch vast quantities of unwanted material that requires lengthy sorting and ultimately goes to waste. Also, the desired specimens are more subject to damage and are likely to be soiled with moth scales that are difficult to remove.

#### *Field work*

Within our region, beetles occur in almost every available habitat from the seashore to the top of Mount Kosciusko and even the most circumscribed suburban garden will harbour an interesting though restricted fauna. Moreover, some field work is always possible at any season of the year. Valuable specimens are liable to turn up in the most unexpected circumstances and places and the enthusiastic collector should never be without some small container in his pocket. Naturally, however, the majority of his better captures will be the results of deliberate and methodical searches.

On the beaches, turning over seaweed and other jetsam above high-water mark will generally reveal a few of the rather large and grey-mottled staphylinids of the genus *Cafius*, together with many smaller members of the family, and dead birds and fish will nearly always afford something of interest to those who have the courage to investigate them: brilliant, shiny green or blue Histeridae (genus *Saprinus*), immigrant Hide beetles (*Dermestes* spp)

and, perhaps, the curious little depigmented staphylinid *Sartallus signatus* Shp. Higher up on the loose clean sand, one can expect to see Tiger beetles (*Cicindela ypsilon* Dej.) running actively in the sun and making short sharp flights when close pursued.

The gravel or mud beside small creeks entering the sea should be examined for small Ground beetles of the genus *Tachys* and then splashed with water to cause others lurking beneath the surface to emerge. Small Pill beetles (Limnichidae and Byrrhidae) and the curious *Heterocerus* species are likely to feature in the catch where the substrate is rich in organic matter. Further inland the same creek should produce a wide range of Carabidae, probably including the handsome green and yellow *Chlaenius darlingensis* Cast. and the black and yellow Bombardier, *Pheropsophus verticalis* Dej. that fires its hot defensive fluid with an audible 'pop'. As one progresses away from the coast and the Dividing Range, into the drier regions, creeks and billabongs become increasingly important foci for many beetles, especially in high summer, and should always be well worked. In the waters themselves there will be a variety of Dytiscidae and other aquatic families awaiting the net and all such habitats should be sampled, ranging from still and brackish to fast-flowing and fresh.

Log rolling is perhaps the most productive means for collecting the many ground-frequenting Carabidae and Tenebrionidae, especially when the soil is not too dry. In the coastal and mountain forests *Notonomus* (Carabidae) and *Cardiothorax* (Tenebrionidae) will be prominent genera, whereas in more open areas these will be replaced by *Sarticus* and *Adelium*, respectively. The rather scarce burrowing carabids of *Carenum* and related genera may turn up occasionally but these are more common in sandy regions further inland; they need to be searched for in winter and early spring, before the heat and drought drive them further underground. Stone turning is generally unproductive in the lowlands but it can be worthwhile in the alpine region, where logs are few and beetles keep close to the surface.

Leaf litter, particularly that from moist fern gullies, can always be relied upon to produce a catch of smaller Carabidae, Staphylinidae, Pselaphidae, etc., together with the black-and-yellow mottled chafer of the genus *Telura* (Scarabaeidae, Melolonthinae). Such litter may be sieved onto the ground-sheet for local inspection, thrown in handfuls into the nearest water, when the beetles will soon struggle to the surface, or brought home in bags for processing in Tullgren funnels. Material from the garden compost heap will also prove productive at any season, if treated in similar ways. Moss is often rather sterile but the denser kind growing in wet situations such as near water falls or on logs or tree-trunks in dense forest, is worth investigating.

Various beetles live or hibernate under the loose bark of living eucalypts and stripping such material over a net or beating tray will often produce a large collection. The smooth-barked gums that regularly exfoliate are most suitable and winter to early spring is the best time of year. Captures

are likely to include a host of smaller Carabidae, mostly striped or spotted in yellow on black (genera *Demetrida*, *Philophloeus*, *Agonochila*, *Amblytelus*, etc.) and in warmer regions, perhaps the brilliant purplish-blue *Aenigma iris* Newm.

Other families almost certain to be well represented are Elateridae (usually by large numbers of dull-coloured *Lacon* and a few of the more attractive kinds); Cleridae (pretty little Checkered beetles and also the large, dull brown *Natalis* species); Chrysomelidae (numerous Leaf beetles of *Paropsis* and related genera); Coccinellidae (Ladybirds, especially the unspotted *Rhysobius ventralis* Er.); Tenebrionidae (including the bright metallic *Chalcopterus* species); Cerambycidae (Longhorn beetles); and Dermestidae (*Trogoderma* spp), that feed upon dead insect remains. Some of these subcortical beetles emerge at night and may then be taken with the aid of a spotlight.

Fallen timber may also prove productive, especially of larvae, the fauna depending upon the state of decay but always including a number of Tenebrionidae. If the bark is still loosely attached and the sapwood moist, the very flat Cucujidae may be expected together with their extraordinary larvae (Fig. 18) and the Carabidae and Histeridae that prey upon them. If sections of the heartwood are permanently wet and punky, the more cylindrical beetles of the genus *Prostomis* (Prostomidae) are likely to be present, perhaps together with a few of the rare family Rhysodidae. On the other hand, relatively recently fallen timber if not too dried out, will more likely yield larvae of the primary borers, of which the Cerambycidae are pre-eminent. Subsequently, when the wood has been riddled and the rot has set in, the Tenebrionidae take over, with a wide range of species suited to every state of disintegration and every level of moisture content. Such timber is also home for colonies of the semi-social Passalidae, whose adults and larvae occur together, and one may well come across larvae of one of the Stag beetles (Lucanidae) in the firmer parts of the same log.

Fallen eucalypt branches that still have the leaves attached and in contact with bare ground afford shelter and food for a number of detritius-feeding Lagriidae, Tenebrionidae, etc., together with predatory Staphylinidae and Carabidae and are always well worth the shifting, provided conditions are not too dry.

Fungi of the toadstool type yield relatively few species but those growing on dead wood are often more productive. Bracket fungi (*Polyporus* spp) on dead or ailing eucalypts should be knocked down and stored in a polythene bag until any larvae present have had time to transform. In this way one is almost certain to obtain plenty of attractive little Erotylidae (genus *Thallis*) and perhaps also some of the larger red-and-black *Episcaphulus*. Fungi growing under damp fallen logs are sometimes almost encrusted with the lovely velvety-red *Lemodes* (Anthicidae) and the Ladybird-like *Stenotarsus* (Endomychidae) occur there more rarely.

Branches of trees and shrubs, if tapped sharply over the beating tray, will yield many of the plant-feeding Chrysomelidae and Curculionidae, especially in the richer coastal forests, but this mode of collecting should preferably be reserved for dull days since many species take to the wing rapidly in hot sunshine, and are often lost. Further inland, the variety of shrubby plants declines but young gum foliage, in particular the 'whipstick' regrowth from stumps left by timber getters, will repay attention. The various feathery-leaved wattles can also be relied upon to produce a good haul. Other plants worth special mention are the primitive Burrawang (*Macrozamia*) of the coastal ranges and the more widely spread Grass-trees (*Xanthorrhoea*). The fruiting bodies of either, if retained in plastic bags, will produce many interesting weevils and the trunks of dead specimens, when dismantled round by round, will certainly be found to harbour predacious Carabidae, Staphylinidae and Histeridae that feed upon the numerous fly maggots present.

Low plants, generally, may be worked with the sweep-net and mixed swamp vegetation can be very productive in this way. Many species that are not active during daylight may be swept at dusk as they ascend the stems to commence their evening flight. In spring, when the ground is moist, good catches of ground-frequenting beetles and their larvae are to be had by pulling up the larger tussock grasses and breaking up their root systems over a white sheet. Many of the larvae taken will be about to pupate, thus affording opportunities both to add adult species to the collection and to elucidate unrecorded life-histories. In the drier areas, spinifex clumps may be treated in the same way, after having been cut off just below ground level with a sharp spade.

Blossom work is perhaps the most appealing method of collecting in the Australian bush and the sight of a good stand of well honeyed bloom, sparkling in the hot sun and fairly teeming with its beetle visitors, is enough to quicken the pulse of any naturalist, young or old. The coastal standstone areas of the Sydney region have long been famous in this way and although now sadly depleted, they are still capable of producing an impressive show. Spring and early summer are the best seasons here, and the December-flowering *Angophora cordifolia* ("dwarf apple" or "heart-leaf apple") is the favoured bush, although some of the *Leptospermum* species (tea-trees), and particularly *L. flavescens* are also very good. Most conspicuous among the visitors are the Jewel beetles (Buprestidae), of which there is an amazing variety of species, most of them belonging to the single great genus *Stigmodera*. Some of the larger kinds are rather wary and confine their attentions to the higher sprays where they are difficult to approach; almost all are quick to take to the wing when disturbed. A light, long-handled net is therefore the best means of capture.

Besides the Jewel beetles, numerous chafers throng the bloom and fall in showers into the net; these are mostly small species of *Phyllocoptes* but the larger, fast-flying Rose chafers, such as *Eupoecila australasiae* Don. and

*Polystigma punctata* Don. are also very conspicuous. Wasp-like Longhorns (Cerambycidae) tax even the trained eye as they move, staccato fashion, over the bloom, in company with their more numerous and forbidding hymenopterous models.

The blossom season becomes progressively later as one ascends the tablelands and higher slopes. Here *Leptospermum* and *Bursaria* provide the main attraction and both can be worked profitably well into February or even early March. Gum blossom is also attractive particularly that of the low, mallee-like *Eucalyptus stricta*, in the Blue Mountains, and the taller Broad-leaved Peppermint (*E. dives*), and Yellow Box (*E. melliodora*) on the tablelands, but much of the latter is normally out of reach. Most wattle bloom comes too early in the season and is generally unproductive but the green wattles (*Acacia mearnsii* and *A. parramattensis*), which flower in summer, are always worth examination. At times and in places where the better kinds of bloom are not available, plants of the heath family (Epacridaceae) may often produce a good capture, as may some of the more floriferous Daisy-bushes (*Olearia*), or even the miserable Cauliflower-bush (*Cassinia*). Single herbaceous flowers, such as Native Yam (*Microseris*) and Bluebells (*Wahlenbergia*) should also be examined.

Dung and carrion are not utilised by beetles here to the extent that one observes overseas, because of the restricted mammalian fauna that was available for exploitation in the past. However, cow and horse dung, as well as that of native marsupials, provided it is not dried out, will produce a number of the scarab genus *Onthophagus*, of which the bronze-black *O. australis* Boisd. is generally the most common. The large, dull orange-brown and black *Ptomaphila lachrymosa* Schreib., one of our very few native Silphidae, is plentiful on carcasses, as are the Devil's Coach-horse beetles (*Creophilus* spp, Staphylinidae) of which there are two closely related local species. The curiously embossed and slow-moving *Trox* species (Trogidae) occur in numbers under mummified carcasses and dried animal remains, together with the smaller Histeridae and Dermestidae. Some particularly fine species of *Trox* occur in the arid regions of the outback, where carcasses dry out quickly and soon become unsuitable for most other beetles.

Highly specialised habitats such as the nests of birds and mammals and the sap exudations from trees attacked by cossid moth larvae, which are much favoured as collecting sites by northern hemisphere coleopterists, are less productive here, presumably because most of them dry out too quickly in our climate to be able to support a continuing fauna. However, such habitats are still worth investigating when the opportunity offers and they may result in some unexpected captures (e.g., the discovery of an entirely new family, Cavognathidae, based upon a species found in magpies' nests, a few years ago).

The nests of ants and to a lesser extent, those of termites, harbour many interesting and highly adapted species of beetles, particularly of the

families Histeridae, Ptinidae and Staphylinidae but the systematic working of such habitats is a specialised study that calls for much patience and dedication.

Of the deliberate trapping methods, light at night is by far the most productive under our conditions. In the outback in particular, where daytime collecting can prove very unrewarding at times, a few hours' work with a light and a sheet, under hot, humid conditions, on a moonless night, can often make all the difference between failure and a most successful trip. Even flightless ground-dwelling species may be attracted to the light and a wider search of the surroundings, with the aid of a hand torch, may well reveal a number of very desirable burrowing carabids of the *Carenum* group as they go about their business on the surface, where none would have been seen in daylight hours. The light should be lit about twenty minutes after sunset in order to attract the early-flying, crepuscular species, as well as those that are active well into the night.

Pitfall traps are perhaps most effective where they can be left *in situ* for extended periods and monitored at frequent intervals but they should not be neglected for long unless provided with some chemical preservative (5% formalin or better, 5% propylene phenoxetol) to prevent deterioration and wastage of captures. For short-term use ordinary tin cans are quite suitable; these should be perforated at the bottom for drainage purposes and sunk up to their rims in the substrate; they may be sited singly in likely-looking depressions or runways, or set in straight rows of three, linked across their tops by a lath of timber: The latter will considerably increase the catch because specimens that would otherwise have passed between the traps will be deflected into them. Baiting with carrion, fish-offal, dung, etc. will further increase and diversify the catch, and even setting for just a night or two should be worthwhile in good localities through which the collector happens to be passing. However, in the interests of conservation, traps should *not* be left *in situ* to continue their action indefinitely in areas that are unlikely to be revisited.

Lastly may be mentioned the household beetles and those of stored products. These are mostly introduced, cosmopolitan species that would scarcely fall within the scope of a work on native insects but as many of them are firmly established in cities and their suburbs and are likely to come to the notice of the general coleopterist, they may be dealt with briefly. The rather large Mediterranean carabid *Laemostenus complanatus* Dej. (16 mm), dull black, elytra with a bluish sheen, is quite frequent in basements and cellars of the older city buildings, where it preys upon other household insects. Before its alien status was recognised, it was redescribed as *L. australis* Blbn. The well known Carpet beetles (Dermestidae), whose larvae damage woollen goods (and insect collections!), include both the established European *Anthrenus verbasci* L. and the native *Anthrenocerus australis* Hope. These are small, rotund beetles, prettily variegated with small coloured scales. They need to escape from indoors every year to feed and mate on nearby flowers.

and hence they are often found wandering over window panes in early summer. Imported Powder-post beetles (Lyctidae) often emerge from household timbers and both native and alien Spider beetles (Ptinidae) also occur indoors, usually in association with dry packaged foods. The small black tenebrionid *Alphitobius diaperinus* Panz. (the Lesser Mealworm) is often very plentiful in fowl-houses and is liable to turn up anywhere in fowl manure. Then there are a number of unimpressive but important species belonging to several families that are to be found in granaries or warehouses, where they attack cereal products and other stores.

### Rearing beetles

Unlike butterflies and moths, beetles are not very subject to wear and tear during their adult lives. Thus the coleopterist is less dependent upon rearing as a source of acceptable specimens than is his lepidopterist counterpart. There are certainly some local beetles that because of a very short adult life span are seldom seen, except as larvae, and in such cases rearing does become important as a means for augmenting the collection. Nevertheless, the main incentives for undertaking this often rather exacting work are probably the intrinsic interest and diversity of beetle life histories and the scope they offer for original observation. Since so many of the local species are quite unknown in their early stages, they present a real challenge to the young enthusiast with the necessary time and patience to rear them through, with the added bonus of a worthwhile addition to scientific knowledge attendant to every success.

The main key to such success is to reproduce as closely as possible the natural conditions under which larvae are found but careful attention to hygiene will also be most important. In general it is the primary feeders that are most readily reared: the leaf-eaters, wood-borers, detritus-feeders and so one. These seldom need more than confinement with the material upon which they feed. Thus, given reasonable control of temperature and humidity, many stored-products species will continue to breed for several generations in a single jar of produce, and most leaf-eating beetles are readily reared in fine-wire cages, provided with a continuous supply of fresh foliage of their choice, together with a layer of damp earth in which to pupate.

Many of the larvae to be found in rotten wood or bracket fungi will complete their development successfully in tins or jars of these materials, with just sufficient ventilation and watering to avoid the extremes of moulding and drying out.

Plastic (polythene) bags, although very useful for field collecting and short-term storage, are readily breached by many boring beetles or larvae and should not be used for rearing purposes unless inspected at frequent intervals. Glass jars of the fruit-preserving type, their lids provided with small ventilation ports and covered with fine wire gauze, are perhaps the most satisfactory

containers for this kind of work. On a smaller scale, plastic-stoppered specimen tubes of various sizes, with just one or two pin holes in the lid, will be found to function very well. Many Dermestidae and Ptinidae are readily reared on a substrate of dried insects confined in this way.

Predaceous species are often difficult to handle unless the specimens are captured when close to being full fed. Problems of disease and of food supply are paramount here, and the longer the larvae need to be maintained, the lower the chances of success. Water beetles (Dytiscidae, Gyrinidae and Hydrophilidae) generally cause less difficulty than terrestrial predators and may often be reared successfully in ordinary aquariums, provided with a suitable supply of small living prey and with the facility to leave the water for pupation. Because of their pronounced cannibalistic tendencies, such larvae should be reared individually in separate containers.

Adult Tiger beetles (Carabidae, Cicindelinae) will mate and lay readily in large vivariums provided with a deep layer of damp sand and the resulting hatching larvae are comparatively easy to rear. Worker termites serve as an ideal food for these and other sedentary carabid larvae, with unspecific feeding habits. Blocks cast from plaster of Paris, which can be kept permanently moist, and which can be made to include cells of various sizes, form ideal containers for the smaller roving predators.

Whenever practicable, larval exuviae should be preserved together with the bred adult, or with an adequate label indicating the identity of the species concerned, for such material will subsequently provide a valuable aid to identification in further work. It will also help to avoid mistakes that could otherwise arise through rearing from mixed cultures. Any parasite that emerges should also be preserved, together with the appropriate data, and later passed over to a specialist in the group concerned.

## Preparing the specimens

### *A. Killing*

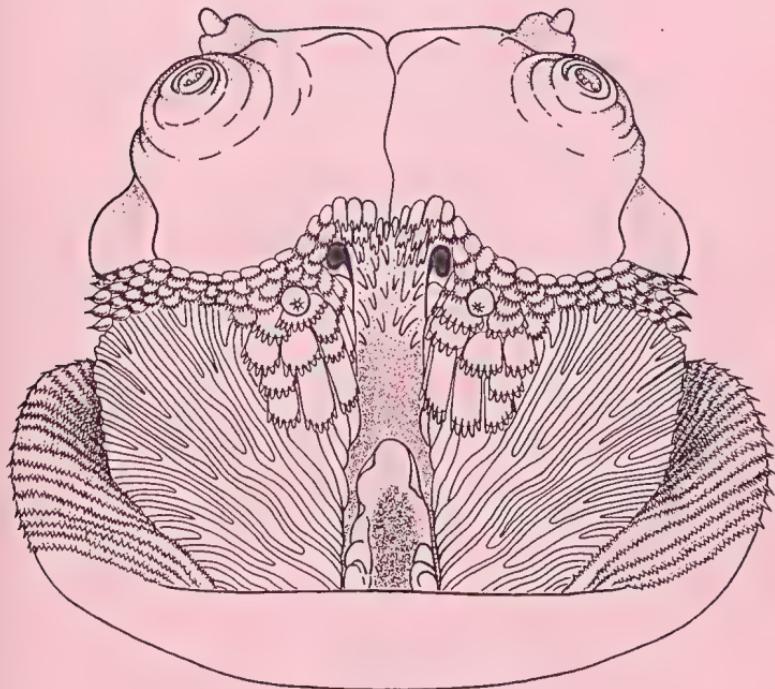
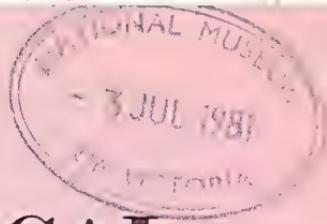
Ethyl acetate (acetic ether) is by far the best general killing agent for beetles since it leaves the specimens perfectly relaxed for setting, although prolonged contact with its vapours can be harmful to certain fugitive colours, particularly the pigment-based reds and greens. This material (which may be purchased at most of the larger chemists' stores) is a colourless and rather volatile liquid with a not unpleasant, somewhat fruity odour. It is non-toxic to humans (except, perhaps, in massive doses) and though inflammable, its flash-point is not dangerously low. Its first action on insects is as an anaesthetic and specimens that are removed from its vapours soon after knock-down are likely to recover. Thus individuals seen at this stage to be badly damaged or otherwise undesirable need not be sacrificed; those that are required should be returned promptly to the killing bottle and left there for at least an hour or, preferably, overnight. By the following morning,





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## COVER

Illustrated by Deborah Kent

Shows the face of the larva, *Tapeigaster annulipes* Macquart (Diptera: Heleomyzidae). The genus *Tapeigaster* is endemic to Australia, where it is widely distributed through temperate regions. The larvae of *Tapeigaster* are known to live in various kinds of fungi.

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# Australian Entomological Magazine

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## THE FOOD PLANTS OF *JALMENUS EVAGORAS* (DONOVAN) (LEPIDOPTERA: LYCAENIDAE)

By T. J. Hawkeswood

Department of Botany, James Cook University of North Queensland,  
Townsville, Queensland, 4811

### Abstract

A new larval food plant, *Acacia ingramii* Tindale, is recorded for *Jalmenus evagoras evagoras* (Donovan) from the Armidale district, New South Wales. The literature giving food plant data for *J. evagoras* (Donovan) is summarized. The 15 known larval food plants, all of which are *Acacia* species, are listed. *Acacia botrycephala* (Vent.) Desf., recorded as a larval food plant of *Jalmenus evagoras evagoras* and *Pseudalmenus chlorinda chloris* Waterhouse and Lyell, should now be known as *Acacia terminalis* (Salisb.) Macbride.

On Christmas Day, 1978, a visit was made to Dangars Falls, about 20 km ESE of Armidale, New South Wales ( $30^{\circ}41'S$ ,  $151^{\circ}44'E$ ). Here five pupae and two second instar larvae of *Jalmenus evagoras evagoras* (Donovan) were collected from a small bush of *Acacia ingramii* Tindale, a food plant previously unrecorded for this butterfly. This species is usually a spreading, bushy shrub growing to 2-5 m in height, but sometimes growing as an erect tree to 7.5 m in height. It is related to *A. neriiifolia* A. Cunn. ex Benth., but differs in its growth habit and has narrower phyllodes with midribs bearing short, stiff hairs (Tindale, 1978). *A. ingramii* is confined to the Dangars and Wollomombi Falls areas, and the Gara and Oaky River districts of the upper Macleay River catchment in north-eastern New South Wales (Tindale, 1978), while *A. neriiifolia* occurs from south-east Queensland to Victoria (Tindale, 1978). Harslett (1965) recorded *A. neriiifolia* as a food plant from near Stanthorpe, Queensland, so it is unlikely that she confused *A. neriiifolia* with *A. ingramii*.

All of the fifteen known food plants of *Jalmenus evagoras* (Donovan) belong to the genus *Acacia*. Thirteen of these are for *J. evagoras evagoras*: *Acacia binervata* DC. (Chisholm, 1925); *A. cunninghamii* Hook. (Manski,

1960); *A. dealbata* Link (Barnard, 1889; Crosby, 1951); *A. decurrents* (Wendl.) Willd. (Froggatt, 1892, 1902; Thorn, 1924; Borch, 1928; Harslett, 1965); *A. falcata* Willd. (Common and Waterhouse, 1972); *A. ingramii* (Hawkeswood, this paper); *A. irrorata* Sieb. ex Spreng. (Common and Waterhouse, 1972); *A. mearnsii* De Wild (Thorn, 1924; Coleman, 1943); *A. melanoxyton* R. Br. (Chisholm, 1925); *A. neriiifolia* A. Cunn. ex Benth. (Harslett, 1965); *A. rubida* A. Cunn. (Common and Waterhouse, 1972); *A. spectabilis* A. Cunn. (Harslett, 1965); *A. terminalis* (Salisb.) Macbride [known prior to Tindale, 1975 as *A. botrycephala* (Vent.) Desf.] (Common and Waterhouse, 1972). Two food plants are recorded for *J. evagoras eubulus* Miskin: *A. penninervis* Sieb. ex DC. (Waterhouse, 1932); *A. harpophylla* F. Muell. (Waterhouse, 1932).

The records by Common and Waterhouse (1972) of *A. falcata*, *A. irrorata*, *A. rubida* and *A. terminalis* (as *A. botrycephala*) are presumably from previously unpublished information. They overlooked Chisholm's (1925) record of *A. binervata*.

*A. terminalis* has also been recorded as a food plant for *Pseudalmenus chlorinda chloris* Waterhouse and Lyell by Binns (1976) where it again appears as *A. botrycephala*.

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## TEMPORAL AND SPATIAL VARIATION OF PARASITISM IN *DANAUS PLEXIPPUS* (L.) (LEPIDOPTERA: NYMPHALIDAE: DANAINAE)

By Myron P. Zalucki

School of Australian Environmental Studies, Griffith University, Nathan, Qld 4111\*

### Abstract

The incidence of parasitism of *Danaus plexippus* (L.) larvae was studied over a one year period. The only parasite reared out of instar III and older larvae was the tachinid *Sturmia convergens* (Wied.). Levels of parasitism ranged from 11% to 100%. Time of year and the size of the food plant patch strongly influenced levels of parasitism, being lowest in winter and in larvae found on isolated plants.

### Introduction

The population dynamics of any species of animal is intimately associated with the density and dispersion of suitable resources. This is especially the case for the larvae of many Lepidoptera which utilise ephemeral or annual food plants. Interactions between the spatial dispersion of the plants and an insect's behaviour and physiological state will determine how many eggs are laid. Similarly, predators and parasitoids of these eggs and the resulting larvae will be influenced by the dispersion of the food plant and of the quarry itself.

In this paper, I attempt to answer two questions: (1) what is the temporal variation in mortality of *Danaus plexippus* (L.) larvae due to parasitoids; and (2) what are the effects of patch size and dispersion of host plants on the levels of parasitism.

The role parasitoids play in the regulation of the levels of butterfly populations is not fully understood (Gilbert and Singer, 1975). Considerable geographical and temporal variation in levels of parasitism have been recorded among field populations of larvae (e.g. Richards, 1940; Dempster, 1967, 1971 for *Pieris rapae*; Urquhart, 1960 for *D. plexippus*; Edmunds, 1976 for *D. chrysippus*). The proportion of parasitism does not always correlate with population trends (Duffey, 1968) although parasitoids have been viewed as important controlling agents in other studies (e.g. Parker and Pinnell, 1972; Varley *et al.*, 1973). Edmunds (1976) has also suggested that the levels of abundance of cryptic, palatable larvae are controlled by predators, whereas those of conspicuous aposematic caterpillars such as those of *D. plexippus* have high mortalities due to parasitoids.

Most studies of populations (and of parasitism) have been confined to pest/crop systems and a good deal of 'text-book ecology' comes from such studies. The monarch/milkweed system provides an opportunity to study host-parasite interactions under non pest/crop conditions. Milkweeds as a resource have a patchy distribution (Zalucki, Chandica and Kitching, in preparation). The influence of patch size and dispersion on parasitism is of interest, particularly in the light of recent theoretical studies of the effects of patchiness on predator-prey and host-parasite interactions (e.g. Hassell and May, 1974; May, 1978).

\* Present address: Dept. of Entomology, University of Queensland, St Lucia, Qld. 4067

### Methods

Between June 1978 and September 1979 seven collections of *D. plexippus* larvae were made from *Asclepias* spp. plants in the Beenleigh and other areas of south-east Queensland (27°43'S; 153°12'E). On each occasion 20-30 plants were thoroughly searched and all larvae removed. These were reared in the laboratory to determine the type and percentage of parasitism. On three occasions larvae were collected from within large milkweed patches and from small isolated clumps (two to five plants within a metre of one another) and single isolated plants. A plant (or clump) was "isolated" if there was no other plant within 50 m. All other collections came from plants within patches. Larvae collected were separated into instars and kept together as a group, being placed into individual perspex tubes upon reaching the fifth instar. The dipterous parasitoids which emerged were kindly identified by Dr D. H. Colless, Division of Entomology, CSIRO, Canberra.

An index of the larval abundance of *D. plexippus* could not be obtained from the samples collected to determine parasitism as variable numbers of plants were searched and these were located in many different positions. An estimate of larval abundance was provided by counts of eggs and larvae on a planted-out patch of sixteen plants. Absolute counts of eggs and larvae were made on this patch (Zalucki, 1980). The monthly egg counts provide a reasonable index of the abundance of *D. plexippus* indicating trends in population changes over a one year period.

### Results

Table 1 lists the collection areas, dates and numbers of each instar collected. All parasitoids reared out of the collected *D. plexippus* larvae were *Sturmia convergens* (Wied.) (Tachinidae). Table 2 summarises the percent parasitism by instar for all collections. No first or second instar larvae contained parasites. Larvae that become parasitised during the third instar

TABLE 1  
Collection dates, sites, patch types and numbers collected in each instar

Date	Site	Patch type*	Nos collected in each instar				
			I	II	III	IV	V
21.vi.78	Beenleigh	P	8	3	2	3	6
11.x.78	Logan Village	P	29	7	11	5	3
13.xii.78	Beenleigh	P	9	3	7	1	7
13.xii.78	Beenleigh	S	18	11	9	1	3
20.ii.79	Beenleigh	P	—	—	2	4	5
20.ii.79	Beenleigh	S	—	—	3	2	—
15.v.79	Beenleigh	P	—	—	4	7	10
15.v.79	Beenleigh	S	—	—	2	4	4
15.vii.79	Nathan	P	—	—	1	4	5
15.ix.79	Sunnybank	P	—	—	10	6	8

\* P = large milkweed patch, diameter >20 m.

S = single milkweed plants or small clump >50 m from nearest other milkweed.

TABLE 2  
Incidence of parasitism by *Sturmia convergens* in larvae of different instars\*

Instar	Number parasitised	Number not parasitised	Death (other causes)	% parasitised
I	0	49	15	0
II	0	24	9	0
III	16	28	8	36.4
IV	22	12	3	64.7
V	40	7	4	85.1

\* Includes both patch and single plant collections.

will usually pupate normally. The parasitoid larvae will then bore out of the pupa, killing it, fall to the ground and themselves pupate. The adult fly emerges one to two weeks later depending on temperature. Occasionally, the parasitoid will burrow out of instar V. Usually one parasitoid emerged per host though on occasions from two to four larvae emerged from a single host. If a third or older instar died it was dissected and checked for parasitoid larvae. If one was found, the *D. plexippus* larvae was scored as parasitised, otherwise such larvae were excluded from the calculation of the figures for percentage parasitism presented in Tables 2 and 3 and Figure 1. As only instars III, IV and V are parasitised the percent parasitism for each sampling occasion is based on these larvae only (Fig. 1, Table 3).

Figure 1 shows the incidence of parasitism over time and patch size. The curve of the population index does not correspond to the dates of collection of parasitoids and offers only an indication of larval population changes over a year. Although based on a small number of larvae on each collection date (Table 3), there is a trend in the incidence of parasitism over the year. From low levels at the end of winter, the incidence of parasitism increases to a peak around the end of summer (Fig. 1).

Assuming that *D. plexippus* shows similar patterns of abundance in successive years, these levels of parasitism are closely associated with the abundance of larvae (Fig. 1). It is, however, unclear whether the decline in *D. plexippus* abundance is due to high parasitism by *Sturmia convergens*, or if *D. plexippus* declines for some other reason such as weather and the abundance of *Sturmia* declines in consequence.

TABLE 3  
Estimated mortality of *D. plexippus* larvae from *Sturmia convergens* parasitoids

Month (1978)	% parasitism by <i>S. convergens</i> P <sup>†</sup>	% parasitism by <i>S. convergens</i> S <sup>‡</sup>	Population index <sup>†</sup>
June	82 (11)*		
July			32
August			
September			
October	11 (19)		7
November			27
December	67 (15)	38 (13)	37
January			
February	64 (11)	20 (5)	71
March			153
April			118
May	100 (21)	50 (10)	39
June			20
July	80 (10)		39
August			28
September	42 (24)		39

\* Figures in parenthesis show numbers of III, IV & V instar larvae collected which did not die of other causes, i.e. of 11 larvae collected in June 1978, 82% were parasitised.

† Egg counts from a cultivated milkweed patch between October 1977 and September 1978. Values refer to total numbers of eggs laid per month.

‡ P = large milkweed patch >20 m diameter

‡ S = single milkweed plants or small clumps >50 m from nearest other milkweed.

The effects of patch size and position are also shown in Fig. 1. Larvae on single or small isolated clumps are significantly less parasitised than larvae from 'large' patches during the same period of time. The percent parasitism of larvae in patches [ $77\% \pm 20$  (SD),  $N = 3$ ] and for "single" plants [ $36\% \pm 15$  (SD),  $N = 3$ ] based on those months when collections were made in each, were significantly different ( $t = 2.3247$ ,  $p < 0.05$ ).

### Discussion

Caution must be exercised in the interpretation of figures for percentage parasitism in field populations when these are estimated by rearing samples of larvae. This is particularly the case if parasitised larvae and pupae are preyed upon selectively by small mammals (Campbell and Sloan, 1977). There is no evidence that mammal or bird predation is a major mortality factor in *D. plexippus*. Both larvae and pupae contain cardiac glycosides (e.g. Dixon *et al.*, 1978) which are vertebrate toxins and, supposedly, confer some immunity to such predation. My own studies on mortality in *D. plexippus* larvae (Zalucki, 1980) indicate that heavy losses due mainly to entomophagous invertebrates occur in the egg, first and second instars. Proportionately fewer larvae are lost in instars III, IV and V. Due to sampling difficulties losses in the pupal stage could not be estimated. Again vertebrate predation may be discounted. The percentage of parasitism in reared field samples will reflect, therefore, actual levels of parasitism in the field.

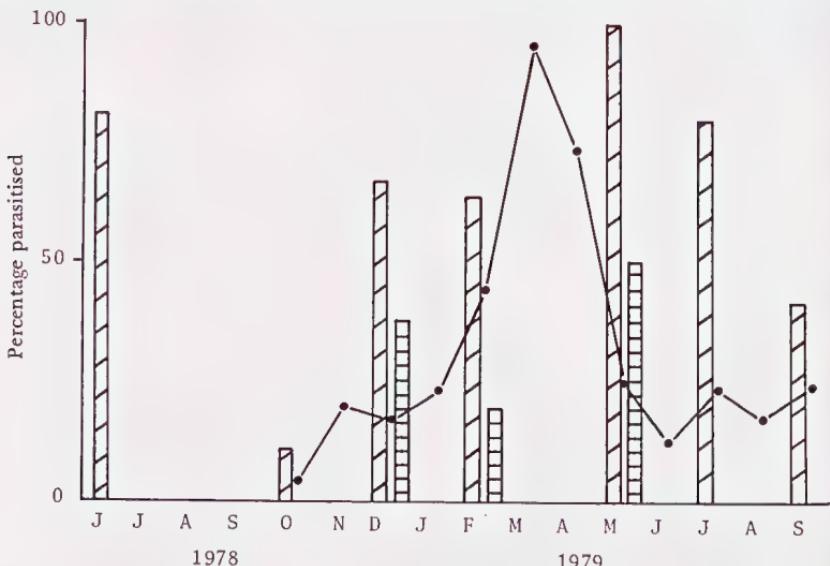


Fig. 1. Percentage parasitism of *D. plexippus* larvae by *S. convergens* over time. Cross hatching refers to larvae in large milkweed patches  $>20$  m diameter, horizontal hatching to larvae on single plants or small clumps  $>50$  m from nearest other milkweed. Population index (---) represents egg counts from a cultivated milkweed patch of 16 plants from October 1977 to September 1978 and indicates population trends only (refer to Table 3 for actual numbers of eggs).

The results for *D. plexippus* agree with Edmunds' (1976) hypothesis (see above). Larvae of *D. plexippus* are cryptically coloured and patterned when viewed from a distance on their host plant, but are brightly, aposematically coloured when viewed close-up. Levels of parasitism in *D. plexippus* larvae (instars III, IV, V) are high, as expected (up to 100%), although losses are also high in the egg and the first and second larval instars due to invertebrate predators from which cardiac glycosides provide no protection.

Changes in levels of parasitism over time show a seasonal trend which seems to correspond to changes in larval abundance of *D. plexippus*. Only long term observations on larval numbers and levels of parasitism will show whether or not the two cycle together and, accordingly, whether parasites are an important factor in population regulation. *Sturmia convergens* has also been recorded as a parasite of the common nymphalid, *Precis villida* (Fab.) and two moths, *Brithys crini* (Fab.) (Noctuidae) and *Agrius convolvuli* (L.) (Sphingidae) (Crosskey, 1973). No doubt there are other hosts. The varying abundance of these alternative hosts will influence the abundance of *S. convergens* and hence levels of parasitism in *D. plexippus*.

The patchy distribution of milkweeds will also influence parasitism. Milkweeds occur in patches of various sizes and show a clumped dispersion pattern (Zalucki, 1980). It is generally accepted that the spatial dispersion of resources, their density and other aspects of environmental heterogeneity such as background vegetation, associated plants, barriers and size, can have significant effects on population colonisation and survival (e.g. Huffaker, 1958; Dethier, 1959; Pimentel *et al.*, 1963; Dempster, 1969; Root, 1973; Cromartie, 1975; Ralph, 1977).

Samples from small isolated patches as opposed to large patches show up to a two-fold difference in the percent parasitism. Given the wide range of patch sizes one might expect a wide variance in levels of parasitism. Only a much more extensive sampling programme encompassing the full spectrum of patch sizes could reveal the statistical relationship between percent parasitism and patch size.

In the only other study of parasitism in *D. plexippus* larvae in Australia Smithers (1973) recorded *Winthemia diversa* (Malloch) as the major tachinid parasitoid and a few specimens of *Sturmia* sp. The absence of *W. diversa* from my own larval collections suggests that perhaps the range of this tachinid does not extend into coastal south-east Queensland. It should be noted that Smithers' results are based on work in and around Sydney. On the other hand the temporal pattern of parasitism levels observed by J. Liddy in Queensland and reported by Smithers (1973) agree with my own observations presented in Fig. 1.

#### Acknowledgements

The author wishes to thank Rhondda Rowe for assistance with larval collection and rearing, Dr R. L. Kitching for his advice and supervision and Dr D. Connell for making facilities available. The author was supported by a C.P.R.A. scholarship.

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## OBSERVATIONS ON THE PREY AND NESTS OF SOME AUSTRALIAN SPIDER WASPS (HYMENOPTERA, POMPILIDAE)

By Howard E. Evans, Mary Alice Evans, and Allan Hook

Department of Zoology and Entomology, Colorado State University, Fort Collins, Colorado 80523, U.S.A.

### Abstract

Prey records are presented for the following species of Pompilidae: *Cryptocheilus bicolor* (Fabricius), *C. distinctus* (Smith), *Priocnemis erythrophorax* (Turner), *Agenioideus nigricornis* (Fabricius), *Batozonellus tricolor* (Smith), *Telostegus nigrocinerascens* (Turner), *Pompilus cinereus* (Fabricius), *Turneromyia melancholicus* (Smith), and *Ctenostegus murrumbidgee* Evans. Nests of *Cryptocheilus distinctus* are described.

### Introduction

Relatively little has been published regarding the prey and nests of the Pompilidae of Australia despite the fact that these are conspicuous elements in the fauna throughout much of the continent. Evans and Matthews (1973) discussed seven species and pointed out notable differences in behaviour among several genera. Many of the morphological differences are doubtless correlated with behaviour patterns, so it is important to describe these when possible. For example, the unusual modifications of the head in some genera are correlated with predation on trap-door spiders (Evans, 1972); the development of the rake on the fore tarsi is correlated with nest and soil type; and the presence of scales on the body of several genera that specialize on orb weavers may well represent an adaptation for escaping from spider's webs, as pointed out for other insects by Eisner (1964).

We describe here the prey and in some cases the nests of nine species of Pompilidae which we studied during the summer of 1979-80. Six of these have not been studied in the field previously. Voucher specimens have been deposited in the collections of the University of Queensland (wasps) and the Queensland Museum (spiders).

### *Cryptocheilus bicolor* (Fabricius)

This large and familiar species occurs over the greater part of Australia. We encountered females with prey on three occasions. On 23 September a wasp was dragging a large spider backwards through a grassy area about 10 m from the Brisbane River, Queensland, holding the spider by either its chelicerae or pedipalps (we could not determine which). From time to time she dropped the spider on the ground while she explored ahead. She was captured as she began to drag her prey into tall grass. The spider proved to be *Heteropoda jugulans* Koch (Sparassidae). At Amby, Queensland, on 27 November, we saw a female *bicolor* attack a large *Lycosa* sp. (Lycosidae) in a dry, sandy creek bed. Our third encounter with the species was near Waroona, in Western Australia, on 11 April. In this instance the wasp was seen behaving in an agitated manner in a clump of dense grass and ferns, in pursuit of a large

spider which fled amongst the vegetation. A few minutes later we parted the vegetation and discovered that the spider [a female *Isopoda leishmani* Hogg (Sparassidae)] had been paralysed. As we tried to take the spider, the wasp defended it vigorously, buzzing loudly and trying to sting a stick we used as a probe. For about five minutes she circled the spider aggressively, when we finally captured her. Evans and Matthews (1973) presented two additional records of Sparassidae as prey.

#### *Cryptocheilus distinctus* (Smith)

We found two females of this species nesting 10 km south of Coonabarabran, New South Wales, 14-17 January. The first was seen digging in a sandy track through eucalypt woodland, scraping the soil into a small pile which was later dispersed (though we did not observe how this was done). The paralysed spider was hanging in the crotch of a dead bush 1.2 m away and 30 cm above the ground. The wasp visited the spider about every five minutes, each time returning to resume her digging. This nest was excavated the following day and found to contain a paralysed spider bearing an egg 3 mm long obliquely on the side of its abdomen. The spider was identified as *Eriophora biapicata* (Koch) (Araneidae). The burrow was oblique, 12 cm long, leading to a cell 6.5 cm deep. The burrow had been tightly packed with sand. The spider was still well paralysed when the burrow was excavated. The second nest was discovered in a search for nests of *Cerceris* (Sphecidae). A plastic cup had been placed over a vertical hole in compact sand, surrounded by a rim of soil. This hole was 1.5 cm in diameter and may have been made by a beetle or one of the larger species of *Cerceris*. A *Cryptocheilus* female emerged into this cup and was found to have made a nest off the side of this burrow, starting 3 cm deep and descending obliquely to a depth of 13 cm. The cell contained a paralysed *Lycosa laeta* Koch (Lycosidae); the egg was dislodged during digging.

We must express some doubt as to the identification of these wasps. *C. distinctus* was described from a male, and pending a revision of the Australian species of this genus, we cannot be certain that these females are properly associated with this species, though it seems likely on the basis of size and coloration.

#### *Priocnemis erythrothorax* (Turner)

This species is characteristic of wet sclerophyll woodland in eastern Australia. We observed a female dragging a spider across a little-used track on the slopes of Mt. Nebo, about 20 km west of Brisbane, Queensland. She grasped the spider by the base of one of the front legs, so that the spider was held in an oblique position. She was taken as she entered dense vegetation. The spider was a female of the family Miturgidae, probably a species of *Uliodon*. The wasp was compared with the type of *erythrothorax* in the British Museum (Natural History) and found to be conspecific.

***Agenioideus nigricornis* (Fabricius)**

A female of this widely distributed species was seen carrying prey in an area of compact sandy clay near Blunder Creek, on the south side of the city of Brisbane, Queensland, on 1 November. She walked forward holding a female *Steatoda femorale* (Thorell) (Theridiidae) in her mandibles. The wasp dropped her prey amongst some leaf litter and appeared to be exploring crevices in the soil when she was captured.

***Batozonellus tricolor* (Smith)**

Observations were made on this species in the same area as the preceding, on 6 December. A female was digging in a sandy road through eucalypt woodland while her paralysed spider lay exposed on the soil 30 cm away. From time to time she returned to her prey briefly, then resumed her digging; each time she appeared to experience difficulty in finding both the prey and the burrow. Wasp and prey were collected, the prey proving to be a female *Poecilopachys australasia* (Griffin and Pigeon) (Araneidae). *Batozonellus* belongs to a complex of genera (including *Poecilopompilus* and *Episyron*) which appear to be specialists on orb-weaving spiders.

***Telostegus nigrocinerascens* (Turner)**

This species was extremely common along a steep bank in a man-made excavation into fine-grained sand at the same locality as the preceding two observations. Nests were often dug into the sides of the vertical bank. Females carried their prey backward, holding one of the spider's legs, and often turned about and flew short distances with their prey. On 4 January a female was seen to fly about a meter with her prey and to land on a branch about 0.5 m above the ground. She was carrying a female *Diaeа evanida* Koch (Thomisidae). Other records for members of this genus suggest that they are specialists on spiders of the genus *Diaeа*.

***Pompilus cinereus* (Fabricius)**

This wasp occurs very widely in the Eastern Hemisphere and in Australia is encountered wherever there is fine-grained sand not far from water. Females characteristically walk forward carrying their prey in their mandibles. There are many published prey records, and we here add several more. In Brisbane, at the same locality as the preceding three observations, we took females with the following prey: *Lycosa palabunda* Koch, *Lycosa laeta* Koch, and *Lycosa* sp. (12 November and 4 January). At Yeppoon, Queensland, on 13 October, we took two females on sandy ridges behind the sea beach, one carrying a paralysed *Lycosa speciosa* Koch, the other *Trochosa expolita* Koch. Although all these records are for Lycosidae, there are numerous records of this species preying on errant spiders of other families (Day, 1981).

### *Turneromyia melancholicus* (Smith)

This wasp was also studied near Blunder Creek, Brisbane. On 8 December, some buzzing was heard in a small pile of sticks at the base of a clay bank in open eucalypt woodland. A short time later a pompilid appeared on top of the sticks and began grooming herself. In a moment she re-entered the pile of sticks and reappeared dragging a paralysed spider behind her, grasping it in her mandibles by the chelicerae or pedipalps. Wasp and spider were taken; the latter proved to be a female *Olios punctatus* Koch (Sparassidae).

### *Ctenostegus murrumbidgee* Evans

Females of this small wasp were seen carrying spiders backward over the soil. The first was at Eungella National Park, about 80 km northwest of Mackay, Queensland, on 17 October. The spider was identified as *Clubiona* sp. A second female was seen digging an oblique burrow in sandy clay soil beneath a picnic table. Males were common in this area and were seen to approach females on several occasions, tending to confirm a sex association previously based only on museum material. Near Blunder Creek, in Brisbane, a female *murrumbidgee* was seen carrying a female *Chiracanthium* sp. She was taken as she tried to free the paralysed spider from a spider's web in which it became entangled. Both of these spiders belong to the family Clubionidae. This is only the third published prey record for members of this large genus: *C. warragai* Evans and *C. buromi* Evans are both reported to prey on *Lycosa* (Evans and Matthews, 1973; Evans, 1976).

### Acknowledgements

For identification of the spider prey, we are greatly indebted to V. Davies and R. McKay, of the Queensland Museum, Brisbane. These studies were conducted while the senior author held a research fellowship in the Department of Entomology, University of Queensland, and a travel grant from the National Geographic Society, U.S.A. Mary Alice Evans held a fellowship from the American Association of University Women. Allan Hook held a grant for dissertation research from the National Science Foundation, U.S.A., No. BNS79-12602.

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## THE FEMALE OF *PSILOPSOCUS PULCHRIPENNIS* SMITHERS AND THORNTON (PSOCOPTERA: PSILOPSOCIDAE)

By C. N. Smithers

The Australian Museum, 6-8 College Street, Sydney

### Introduction

Smithers and Thornton (1973) reviewed the species of *Psilopsocus* Enderlein of New Guinea and gave a key to the five known species of the genus. As male material only of *Psilopsocus pulchripennis* Smithers and Thornton was available the female could not be described. A female which corresponds in general features with the male and which is almost certainly that of *Ps. pulchripennis* has now been found amongst material on loan from the Bernice P. Bishop Museum, Honolulu. This is described here.

### *Psilopsocus pulchripennis* Smithers and Thornton

#### DESCRIPTION OF FEMALE

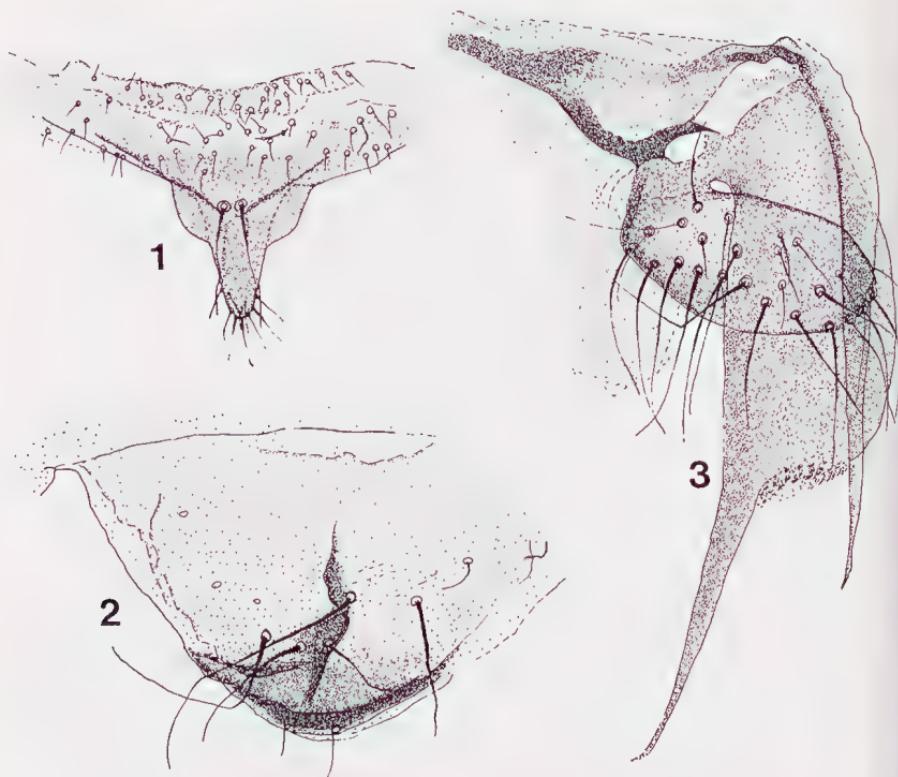
**Coloration** (in alcohol). As in male, the pigmented areas are little more extensive but the pattern the same.

**Morphology.** Length of body: 3.4 mm. Median epicranial suture distinct but fine. Lengths of flagellar segments:  $f_1$  : 0.96 mm;  $f_2$  : 1.00 mm. Pubescence of flagellar segments fine. Eyes fairly large but not reaching level of vertex. Ocelli small. Apex of lacinia divided into the usual small internal cusp and broader external cusp, the latter divided into about six sharply pointed teeth, the inner smaller than the outer; apices of left and right lacinia differ in detail of tooth arrangement. Hind femur fairly short. Hind tibia with row of ctenidiobothria along ventral surface as well as less well developed ctenidia generally distributed over surface. Fore and middle tibiae similarly bearing ctenidiobothria but without strongly developed ventral row. Measurements of hind leg: F: 0.72 mm; T: 1.40 mm;  $t_1$  : 0.49 mm;  $t_2$  : 0.084 mm;  $t_3$  : 0.14 mm; rt: 6.0: 1: 1.65; ct: 17, 1, 1. Fore wing length: 5.0 mm; width: 1.6 mm. Venation and wing form as in male. Epiproct (Fig. 2). Subgenital plate (Fig. 1). Gonapophyses (Fig. 3).

**MATERIAL EXAMINED.** NEW GUINEA: 1 ♀, Bulldog Rd., about 14 km south of Edie Creek, 2405 m, 4.vii.1966 (G. A. Samuelson).

### Discussion

The female of *Psilopsocus pulchripennis* will run out in the key provided by Smithers and Thornton (1973, p. 103). It differs from that of *Ps. nigricornis* Enderlein in wing pattern and form of the gonapophyses. In *Ps. nigricornis* the dorsal valve tapers gradually to its recurved point whereas in *Ps. pulchripennis* it narrows abruptly about half way along its length and then tapers to a fine point as in *Ps. marmoratus* Smithers and Thornton. It differs



Figs 1-3. *Psilopsocus pulchripennis* SM. and TH. ♀: (1) subgenital plate; (2) epiproct; (3) gonapophyses.

from that species in lacking the small median seta on the posterior lobe of the subgenital plate and the sclerified bars associated with the entrance to the spermatheca are longer.

#### Acknowledgements

I would like to thank Dr J. L. Gressitt for the loan of Psocoptera material, the Australian Research Grants Committee for financial support for work on the Psocoptera and Mr M. Robinson for preparing the illustrations to this note.

#### Reference

Smithers, C. N. and Thornton, I. W. B., 1973. The Psiloscoidae (Psocoptera) of New Guinea. *Proc. Linn. Soc. N.S.W.* 98(2): 98-103, 13 figs.

## AN AID FOR COLLECTING BARK-INHABITING INSECTS

By C. E. Chadwick  
1/155 Herring Rd, North Ryde, N.S.W.

Many species of insects, especially Hemiptera and Coleoptera, shelter under bark. Eucalypts, with reasonably loose bark and a smooth trunk, e.g. *Eucalyptus tereticornis* and *E. haemastoma*, are well patronised and are good spots for winter collecting.

Frequently pieces of bark are too strongly attached to be lifted by the fingers or by a screwdriver, which is sometimes used, and desirable specimens are able to escape. A simple and effective aid to remove such bark can be made from the end of a discarded car spring and a short length of garden hose.

A car spring is made of slightly curved flexible steel and is thinner and rounded at each end. A piece about 25 cm long taken from one end forms the basis of the gadget. Using an oxy-acetylene blow torch metal is cut from each side of the selected piece to leave a central section about 1.5 cm wide and about 10 cm long to act as a handle (Fig. 1). A piece of garden hose of appropriate length and diameter may then be forced over the handle. The measurements given have been found appropriate, but may be varied to suit the collector's needs.



Fig. 1

The thin rounded edge at the end of the spring enables it to be inserted under bark with ease, while the curved flexible steel and the handle give it considerable leverage. This tool is much more effective than fingers or a screwdriver and its cost is very low. It can be made from discarded materials and almost any metal workshop or garage could cut the handle to shape for a small charge. The tool can be used for digging in very limited areas, and was originally made by Mr L. I. Cady of Kiama for digging up terrestrial orchids.

## FIRST RECORD OF *APATURINA ERMINEA* (CRAMER) (LEPIDOPTERA: NYMPHALIDAE) FROM AUSTRALIA

By G. A. Wood

P.O. Box 83, Herberton, N. Queensland 4872

### Abstract

A single male of *Apaturina erminea* is recorded from Iron Range, N. Queensland, this being the first specimen taken in Australia. The subspecific status of the specimen is uncertain.

*Apaturina erminea* (Cramer) is a large, fast flying and conspicuous butterfly with a wide distribution in the Australian region. It occurs in the Moluccan islands, through New Guinea to the Solomon Islands and D'Abra (1978) recognises nine subspecies.

A single male of this species was taken by me at Iron Range, Cape York Peninsula, N. Queensland, on 8 July 1980. I disturbed the specimen while it was resting as I walked up the track of Mt Lamond. It flew for several seconds then landed on a tree trunk with its head downwards and wings held above its body. It was in near perfect condition and is now retained in my collection.

The existence of this species at Iron Range has been known for a number of years. It was first brought to my attention in 1974 by Alan Ey who observed it in November of that year. In December 1978 I observed males on two occasions flying rapidly along tracks in rain forest.

There appears to be little difference between the single Australian male and males of the subspecies *A. e. papuana* Ribbe from Papua New Guinea contained in the collection of M. Cermack. Until further material is available the subspecific status of the Australian specimen must remain unresolved.

### Reference

D'Abra, B., 1978. *Butterflies of the Australian region*. Second edition. Lansdowne, Melbourne. 415 pp.

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## FOURTH INTERNATIONAL CONFERENCE ON WILD LIFE DISEASES AUGUST 23 - 28, 1981; SYDNEY, AUSTRALIA

Major subject areas for papers and discussion will include: Wildlife diseases in the Pacific Basin, Parasitology, Microbiology, Epidemiology and Toxicology. Sessions will be held in the Conference Centre, Taronga Park Zoo. It is anticipated that there will be 100 submitted papers and already the offers of 60 have been received.

Enquiries should be directed to: Congress Secretariat, G.P.O. Box 2609, Sydney, N.S.W. 2001. Telephone: (02) 241 1478

## BOOK ANNOUNCEMENTS

*Proceedings of the 2nd Australasian conference on grassland invertebrate ecology.* Palmerston North, New Zealand, 22-26 May 1978. Sponsors: D.S.I.R. and N.Z. Ministry of Agriculture and Fisheries. Edited by T. K. Crosby and R. P. Pottinger. Government Printer, Wellington. 1980. 294 pages. Price: NZ\$12.00 plus postage (Australia & S. Pacific \$4.00; Asia & N. America \$5.00; Europe, S. America, & Africa \$8.00).

The 75 contributions deal with the role of invertebrates in nutrient cycling and energy flow, invertebrate population dynamics, invertebrate-plant relationships and breeding pest-resistant plants, insect damage assessment and survey techniques, dispersal and establishment of pests, chemical and cultural control of pasture invertebrates, development of pest management systems, biological control of pasture invertebrates, and systems analysis and simulation modelling.

The contributions underscore the importance of pastoral farming to the Australian and New Zealand economies. Furthermore, they demonstrate that the study of the grassland fauna, both the beneficial and pest species, assumes a much more important role than in the Northern Hemisphere which does not have the range of indigenous and exotic pests established as in Australasia.

*Orders to:* Scientific Liaison Officer, Entomology Division, DSIR, Private Bag, Auckland, New Zealand. Payment should accompany orders.

*W. M. Maskell's Homoptera: species-group names and type-material* by L. L. Deitz and M. F. Tocker. 1980. *New Zealand DSIR Information Series* 146: 76 pp. Price: NZ\$3.00 (plus postage to countries outside N.Z. as follows: Australia and Pacific, \$1.50; N. America and Asia, \$2.50; Europe, S. America, Africa, and Middle East, \$3.50).

Maskell who lived in New Zealand was one of the first researchers to describe economically important Homoptera. Between 1879 and 1898 he described over 300 species, mainly Coccoidea (scale insects); several of these are well-known plant pests such as bluegum scale, citrophilous mealybug, coconut mealy bug, cottony cushion scale, red wax scale, and woolly whitefly. Because Maskell became recognised as a world authority, researchers from countries outside New Zealand sent him specimens for identification and description. As a result the Maskell Collection, now held by the N.Z. Arthropod Collection at Entomology Division, DSIR, Auckland, contains irreplaceable type specimens of 20 countries (e.g. Australia, U.S.A., China, Japan and South Africa).

Many species have subsequently been restudied, and some specimens have been retained in other collections. Therefore Dr Deitz and Mrs Tocker decided to document exactly the type material holdings of the Maskell Collection in N.Z., and to document the holdings and elucidate the type status of all other Maskell type specimens in other collections. This bulletin is the result of their painstaking research.

The species group names in Psylloidea, Aphidoidea, Aleyrodoidea and Coccoidea are listed alphabetically by trivial name under the family to which they are at present assigned. Each entry includes a citation of the original description, type locality, institutions holding type material, and one or more references to recent family and generic placement. Lectotype designations are given for 28 entries.

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## BOOK REVIEW

*Scientific and common names of insects and allied forms occurring in Australia.* Compiled for the Standing Committee on Agriculture, Entomology Committee by P. B. Carne, L. D. Crawford, M. J. Fletcher, I. D. Galloway and E. Highley, Commonwealth Scientific and Industrial Organization, Australia. 1980. Available from C.S.I.R.O. Editorial and Publications Service, 9 Queens's Rd, Melbourne. \$4.00 per copy, post paid.

This long awaited list is a most welcome addition to the bookshelf, replacing earlier editions published as *C.S.I.R.O. Bulletins* between 1955 and 1973. These earlier issues focussed on insects of economic importance, striking appearance or those that are very common. This edition gives greater representation to other groups, especially molluscs and spiders.

It consists of four parts, a comprehensive explanatory Introduction, and Index of Scientific Names, an Index of Common Names and a Systematic List. Previous editions had only two alphabetical lists; scientific names and common names. This handbook includes a third most important taxonomic list, placing groups in systematic sequence from phylum to order; families, genera and species are listed alphabetically within orders. The taxonomic list can be easily utilized because the order of each species is given in both scientific and common name lists.

Changes in scientific nomenclature are covered, prior names are entered in the scientific list and the user is referred to the species under its current name. Changed common names are similarly treated. Where no common name exists, descriptive phrases have been employed.

Standardizations have been applied to fusion, hyphenation and separation of words in common names; these changes being common sense and well overdue. For example, where common names consist of two parts, one indicating the family or group, the other a modifier they are separated (e.g. christmas beetle); where the common name does not have taxonomic indicators, they are fused (ladybird, greenfly). Generally, hyphens are eliminated. Exotic species introduced for biological control are marked in the Systematic List.

I can find no errors in the families with which I am familiar—some taxonomists may disagree with the arrangement of the Systematic List and one could quibble over many of the common names, but the new format seems eminently sensible.

In summary: an essential reference booklet.

J. M. E. ANDERSON  
School of Zoology,  
University of New South Wales

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Compiled by M. S. Moulds

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## COVER

### Illustrated by Deborah Kent

Shows the face of the larva, *Tapeigaster annulipes* Macquart (Diptera: Heleomyzidae). The genus *Tapeigaster* is endemic to Australia, where it is widely distributed through temperate regions. The larvae of *Tapeigaster* are known to live in various kinds of fungi.

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# Australian Entomological Magazine

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Volume 8, Parts 2, 3



## PREDATION ON *OGYRIS GENOVEVA* (LEPIDOPTERA: LYCAENIDAE) BY MEAT ANTS

By P. R. Samson and C. F. O'Brien

Department of Zoology, Australian National University, Canberra, A.C.T. 2600

and

217 Raymont Road, Alderley, Qld. 4051

A large larval colony of *Ogyris genoveva gela* Waterhouse was found near Canberra in April, 1979, in a nest of the sugar ant *Camponotus consobrinus* (Erichson) at the base of a eucalypt. Larvae were clustered on the trunk at the nest entrance and others were sheltering beneath a rock at the base of the tree. The rock could not be replaced securely so the colony was covered by pieces of bark.

On 4 November, 1979, a large number of meat ants, *Iridomyrmex purpureus* (Fr. Smith), were observed attacking the colony. Many larvae were still being attended by sugar ants at the nest entrance, but some were wounded. A larva was seen being carried away by the meat ants.

No meat ants were found at the colony site when it was re-visited on 25 November, but larvae and sugar ants were present. The survival of the colony suggests *O. genoveva* is protected from predators to some extent by its association with *Camponotus*.

Predation by meat ants on another species of *Ogyris*, *O. abrota* Westwood, was observed by Thorn (1924).

### Acknowledgements

We wish to thank Dr R. W. Taylor, C.S.I.R.O., Division of Entomology, Canberra for identifying the ants involved.

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## FLY MIMICRY BY A JUMPING SPIDER (SALTICIDAE)

By N. H. Morrison

14 Tarraleaf Cres., Lyons, A.C.T., 2606.

Jumping spiders are fairly conspicuous and easily recognised creatures but relatively little is known of their biology. In general, the species found in the southern half of Australia are drab, however, in the genus *Saitis* the males are often vividly marked (Main 1976).

Recently, a male of this genus was observed and identified as *Saitis piscular* Keyserling (M. R. Gray, pers. comm.). The colours were quite breathtaking when viewed through a stereomicroscope. The front of the cephalothorax is a rust-brown, the rest of the cephalothorax black. The abdominal colouration is green with vivid red markings. The third pair of legs are covered with dense black setae and consequently this pair appear much thicker than the others. The palps are white and stand out against the rust-brown of the face (Clyne 1969).

The behaviour of this spider was most unusual. As it moved across the leaves it raised its third pair of legs and, holding them straight and angled to the rear, it waved them in a hesitant fashion. The total effect was exactly like the courtship wing-waving indulged in by the small flies of the Sepsidae, Trypetidae and Dolichopodidae (Oldroyd 1964). This effect was enhanced by the colouration of the spider and it could easily be mistaken for such a fly. Only when the third pair of legs were lowered did the characteristic salticid shape become obvious.

Most, if not all, of the jumping spiders indulge in elaborate courtship 'dances'. The movements and postures of the male involve angling or turning the body, various movements of the palps and also of the legs. The first pair of legs are generally used and can also be used for antagonistic postures (Forster 1977b) and in an activity termed 'groping' which may be a searching for anchor lines (Forster 1977a). Many records exist of these spiders waving their front legs during courtship (Forster 1977a, Forster and Forster 1973, Bristowe 1958, McKeown 1936) and at least two species use their third pair of legs as part of their display (Forster and Forster 1973, McKeown 1936).

It is therefore possible that the observed behaviour was either courtship or aggression but at the time no other spider was seen in the immediate vicinity. The spider was kept in captivity for a couple of days and fed with small insects. During this period it was kept alone and the 'wing-waving' was observed on several occasions, once immediately prior to taking food. Thus it appears that the 'wing-waving' is true aggressive mimicry with the spider apparently gaining some hunting advantage in adopting a fly-like appearance. Conversely, a brightly coloured animal which is the potential prey of a wide range of larger predators has little to lose regardless of its pose and must rely on speed to escape predation.

### Acknowledgements

I am grateful to Mr M. S. Upton, C.S.I.R.O., Division of Entomology, Canberra, A.C.T., for his helpful comments and Mr M. R. Gray, Australian Museum, Sydney, for identifying the specimen.

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## MUSCA CASSARA PONT (DIPTERA: MUSCIDAE): A FIRST RECORD FOR THE AUSTRALIAN MAINLAND

By Donald H. Colless

Division of Entomology, CSIRO, Canberra, ACT, 2602

In his review of the Australian Muscidae, Pont (1973) decided that the species previously known as *Musca lucens* Villeneuve had in fact never been formally described; in his opinion Villeneuve's description refers to another species (*Musca conducens* Walker). Pont therefore supplied a full description and the name *Musca cassara*. He recorded the species from various parts of the Oriental Region, the Solomon Islands, and Prince of Wales Island in Torres Strait; but he found no evidence that it occurs on the Australian mainland.

I can now report that *M. cassara* is quite common in the vicinity of Cooktown, northern Queensland. During a visit in September-October, 1980, numerous specimens were taken between Mt. Webb, some 50 km to the north of the town, and Shipton's Flat, some 35 km to the south. The material has been compared with Pont's description, and with a paratype female in the Australian National Insect Collection. Its identity is not in doubt.

During his (1973) review, Pont studied almost every specimen of Australian *Musca* held in a major collection. There are, therefore, grounds for believing that, at some time during (say) the last 20 years, *M. cassara* arrived on the Australian mainland, probably in the vicinity of Cape York, and is currently spreading south. Its abundance seems closely correlated with that of cattle and one might fairly suspect that it breeds in dung. There would seem, therefore, little or no impediment to its reaching (at least) Cairns and the Atherton Tableland in the near future.

In appearance *M. cassara* is not unlike the bushfly *M. vetustissima* Walker, but can be immediately distinguished by: (a) thorax with longitudinal dark vittae completely fused on each side, yielding two broad, dark, parallel bars, separated by about their own width and extending over almost the whole length of the mesonotum; (b) bend of vein  $M_1$  rounded, rather than angulate; (c) dust on thorax and abdomen golden, rather than grey (this very conspicuous when specimen viewed from behind). In (a) and (b) there is a close resemblance to *Morellia hortensis* (Wiedemann), which also occurs in northern Queensland. However, that species has a generally black, rather than golden facies; the upper surface of the wing has no setulae on the stem-vein (*cassara* has 1-2); and the discal cell has a large basal area devoid of microtrichiae (uniformly microtrichiose in *cassara*).

I would be glad to receive records and/or specimens that might help plot the (expected) spread of *M. cassara*.

### Reference

Pont, A. C., 1973. Studies on Australian Muscidae. IV. A revision of the subfamilies Muscinae and Stomoxinae. *Aust. J. Zool., Suppl. Ser.* 21: 129-296.

## A NEW SPECIES OF *DIRLA* NAVAS (PSOCOPTERA: CALOPSOCIDAE) WITH COMMENTS ON THE POSITION OF THE GENUS

By C. N. Smithers

The Australian Museum, 6-8 College Street, Sydney, 2000.

### Abstract

A new species, *Dirla pulleni*, is described from New Guinea and the position of *Dirla* in the Calopsocidae confirmed.

### Introduction

*Dirla* Navas is one of five genera included in the Calopsocidae. Little information had been published on it since the somewhat meagre description of the single specimen of the type species, *D. javana* Navas (Navas 1924), until New (1978b) described two more species. He also provided (New 1977) a redescription of the female of *Callistoptera* Enderlein (the male is still not known) and has described and given a key to the three known species of *Neurosema* McLachlan as well as a key to the genera of Calopsocidae (New 1978a) adding the fifth genus, *Nemupsocus* New (1978b) for a single New Guinea species.

Material of a fourth species of *Dirla*, the second from New Guinea, is described here. The position of the family has been discussed (Smithers 1967) on the basis of *Calopsocus* Hagen.

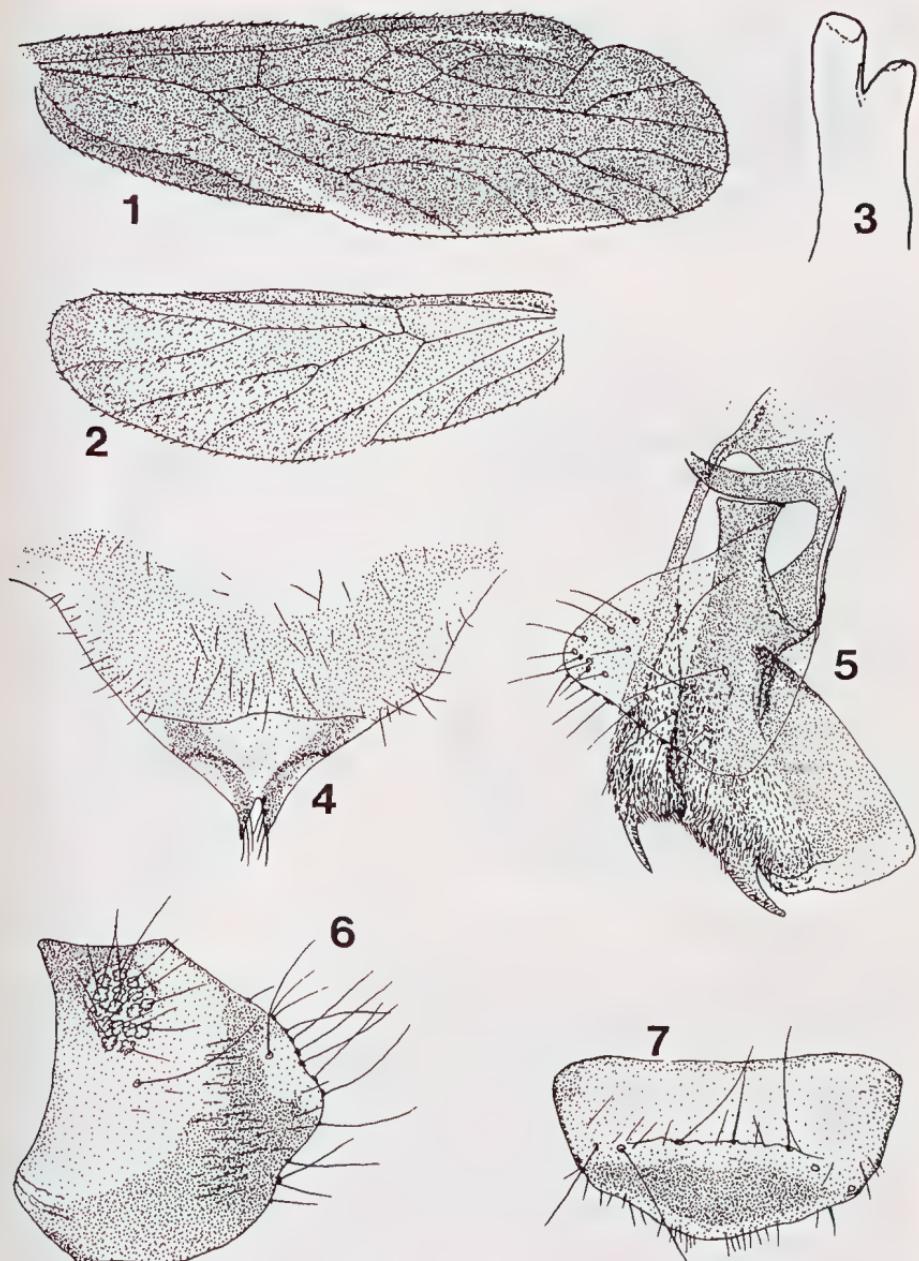
### *Dirla pulleni* sp. n.

(Figs 1-12)

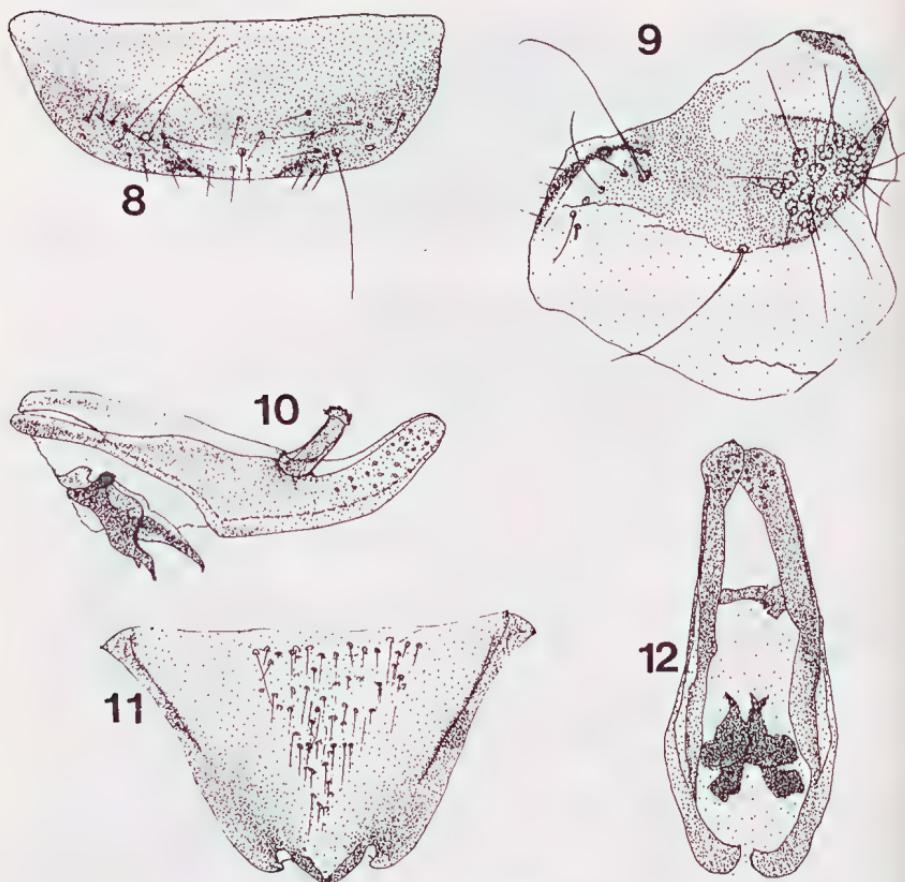
#### FEMALE

**Coloration** (pinned specimen). Head red with a small yellow patch dorsal of each antenna base. Epicranium a little darker red than rest of head. Labrum red. Scape and pedicel red; first flagellar segment yellowish except for almost black tip, setae correspond in colour to segment colour; second, third and fourth flagellar segments black with very long, dense, black pubescence; remaining flagellar segments black with black setae but segments shorter and setae less dense. Eyes black. Ocelli pale, tubercle red. Maxillary palp reddish with black distal half of fourth segment. Thorax and legs reddish brown, tips of tibiae and first tarsal segments black, second segment wholly black. Fore wings (Fig. 1) with membrane mostly brown, a narrow pale border along hind margin from  $M_1$  to nodulus, the pale area a little wider towards nodulus than distally; very narrow pale area borders divergence of  $R_{2+3}$  from  $R_{4+5}$ . Veins dark brown. Hind wing (Fig. 2) paler brown than fore wing. Abdomen very dark brown, almost black.

**Morphology.** Length of body not measured owing to collapsed state of abdomen. Median epicranial suture distinct. Vertex with a few erect setae. Postclypeus not very bulbous. Antennae arise from small cup-shaped protuberances. Length of flagellar segments:  $f_1$ : 1.36 mm;  $f_2$ : 0.92 mm. Setae of middle region of antenna, i.e. flagellar segments 2, 3 and 4, very long giving a narrow "bottle brush" appearance to the antenna. Eyes large, just reaching level of



Figs 1-7. *Dirla pulleni* sp. n. ♀. (1) fore wing; (2) hind wing; (3) lacinia; (4) subgenital plate; (5) gonapophyses; (6) paraproct; (7) epiproct.



Figs 8-12. *Dirla pulleni* sp. n. ♂. (8) epiproct; (9) paraproct; (10) phallosome, left lateral view; (11) hypandrium; (12) phallosome, dorsal view.

vertex. IO/D (Badonnel): 2.2; PO: 0.9. Ocelli small, tubercle hardly developed. Outer margin of mandible semicircular. Lacina (Fig. 3). Claws with preapical tooth; pulvilli broad. Legs very hairy. Measurements of hind leg: F: 1.36 mm; T: 2.32 mm;  $t_1$ : 0.64 mm;  $t_2$ : 0.20 mm; rt: 3.2: 1; ct: 19, 2. Fore wing length: 6.7 mm; width: 2.1 mm. Fore wings slightly curved longitudinally. Anterior margin notched at distal end of pterostigma at which point wing has a transverse fold along distal margin of pterostigma into spur vein. Costa broken at base of pterostigma and at distal fold. Sc absent. Rs recurrent at base. Rs and M fused for a very short length. Secondary veins restricted to area behind pterostigma. Margin, veins and wing membrane setose. Hind wing length: 5.1 mm; width: 1.7 mm. Rs recurrent at base, Rs and M branched, the branches somewhat sinuous; Rs and M fused for a short length. Epiproct (Fig. 7) short, heavily sclerotized, with a row of long setae across middle and a setose slightly curved hind margin. Paraproct (Fig. 6) well sclerotized, broad, with a circular field of

large trichobothria with one long adjacent seta and a row of smaller setae; a few small setae occur on distal half of paraproct those nearer hind margin longer. On its internal face there is a field of small setae arising from large alveoli. Gonapophyses (Fig. 5) well sclerotized; ventral valve divided, strongly spiculate in distal half; dorsal valve very broad with apical, ventral spur, strongly spiculate; external valve well developed, setose. Ninth tergite well sclerotized. Subgenital plate (Fig. 4) well sclerotized, extended posteriorly by a strongly sclerotized, apically setose, lateral bar on each side between which the plate is membranous; the bars converged posteriorly.

#### MALE

*Coloration* (pinned specimen). As female but with first flagellar segment black.

*Morphology.* Length of body not measured owing to collapsed state of abdomen. Median epicranial suture distinct. Vertex rounded with sparse, erect setae. Postclypeus hardly bulbous. Antennae without excessive development of setae on second to fourth flagellar segments. Eyes large, just reaching above level of vertex. IO/D (Badonnel): 0.8; PO: 1.3. Ocelli small, tubercle hardly developed, anterior ocellus much smaller than lateral ocelli. Length of flagellar segments:  $f_1$ : 1.4 mm;  $f_2$ : 0.096 mm. Lacinia as in female. Measurements of hind leg: F: 1.32 mm; T: 2.36 mm;  $t_1$ : 0.64 mm;  $t_2$ : 0.20 mm; rt: 3.2 : 1; ct: 22, 2. Fore wing similar to that of female but smaller. Fore wing length: 5.7 mm; width: 2.0 mm. Hind wing length: 4.2 mm; width: 1.5 mm. Epiproct (Fig. 8). Paraproct (Fig. 9). Hypandrium (Fig. 11). Phallosome (Figs 10, 12).

**MATERIAL EXAMINED.** NEW GUINEA: 1 ♀ (holotype), Western Highlands, Jimi River, 1600 m, 16.vii-21.ix.1961, W. W. Brandt; 2 ♂ (allotype and paratype), Daimandi, 1200 m, Finisterre Range, Madang Centr. Subdistr., x.1964, R. Pullen. Holotype ♀, allotype ♂, in Australian National Insect Collection; ♂ paratype in Australian Museum.

#### Discussion

The description of *Dirla javana* is fairly brief but *D. pulleni* clearly differs from it in being much larger, in having the costal margin of the fore wing more strongly curved at the pterostigma, in having the fore wings more elongate and, in the hind wing, the bifurcation of M much closer to the wing base than the bifurcation of Rs. Genitalia of *D. javana* have not been described. In *Dirla furcata* New the fore wing is much broader in relation to its length than in *D. pulleni* and the phallosome sclerifications of the former are in the form of a series of long, posteriorly narrowed or pointed rods. In *D. navasi* New, known only from the female, the ventral valve of the gonapophyses is much narrower apically and the lobes of the subgenital plate rounded, not pointed. *Dirla* agrees with the other genera of the family Calopsocidae in several features. 1.—The wing membrane is setose. 2.—There are secondary veins in the fore wing although in *Dirla* these are restricted to the area immediately behind the pterostigma (i.e. between  $R_1$  and Rs); they are less extensive than in

*Neurosema* and *Calopsocus* but moreso than in *Callistoptera* and *Nemupsocus*. The homologies of the veins in this area of the wing have not been critically studied in the Calopsocidae but for the present it is assumed that the vein behind the pterostigma is  $R_{2+3}$  and the fork just anterior to the wing apex is  $R_4$  and  $R_5$ ; these latter veins are not usually present as separate entities in the Psocoptera and the current interpretation may need revision. 3.—*Dirla* has a preapical tooth on the tarsal claws and a broad pulvillus [as in other Calopsocid genera except *Callistoptera* and *Nemupsocus* which lack the tooth (New 1977, 1978b)]. 4.—In males the phallic frame is broken or weakened anteriorly, the internal and external parameres are strongly upturned posteriorly and there are very strong sclerifications associated with the penial bulb. 5.—The ninth tergite of the male is very strongly sclerotized and has extensive rugose areas and a median comb along the hind margin; this comb is sometimes medially absent. 6.—In the female both the ventral and dorsal valves are divided except for the acuminate ventral valve in *Nemupsocus*. 7.—The female subgenital plate has a membranous posterior lobe which is strengthened along each side by a strongly sclerotized, apically setose bar; the lobe is attached by a membranous connection to the body of the plate. The lateral strengthening bars are very easily detached during preparation of the specimen; the sclerite attached to the gonapophyses in the illustration of *Callistoptera anna* Enderlein in New (1977, Fig. 7) is almost certainly part of a similar distal lobe of the subgenital plate as suggested by him (New 1977: 54).

When discussing *Callistoptera* New (*loc. cit.* p. 54) defined a monogenetic subfamily to contain it. *Dirla* does not conform to his definition except in having  $R_4$  and  $R_5$  separate in the fore wing and is, therefore, to be excluded from it. It is clear on the basis of material now available that *Dirla* should be retained in the Calopsocidae and is best retained in the Calopsocinae.

#### Acknowledgement

I would like to thank Mr M. S. Upton for making material of *Dirla* available for study.

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## REDESCRIPTION OF *PARASARCOPHAGA REPOSITA* LOPES (DIPTERA: SARCOPHAGIDAE)

By B. K. Cantrell

Entomology Branch, Department of Primary Industries, Indooroopilly, Qld 4068.

### Abstract

The male of *Parasarcophaga reposita* Lopes is redescribed and the female and immature stages described for the first time.

### Introduction

This species was described by Lopes (1959) from a single male specimen in the Australian National Insect Collection, CSIRO, Canberra. This specimen is now in a very poor condition with only the head, thorax and forelegs remaining, and all the major bristles and both wings missing. In addition, a large part of the specimen is covered with a fine fungal mat. The specimen bears the data: Sydney, N.S.W. Bred 1902. Feeding in a spiders cocoon.

During 1980, I received adults and immature stages of a sarcophagid reared from the egg cases of *Cyrtophora moluccensis* (Doleschall) (Araneidae) from Queensland and Papua New Guinea. Comparison of the aedeagus and claspers with Lopes' illustrations, together with the unusual host association allowed me to identify them as *Parasarcophaga reposita* Lopes. Since this species is only known from the holotype, the opportunity is taken to describe the other stages.

The host relationship of this species is most interesting (Lubin, 1974), as larvae of other Sarcophaginae feed either in decomposing organic matter or as internal parasites of insects. So far *P. reposita* has only been reared from *C. moluccensis*, and it would be interesting to examine the egg cases of other large spiders for parasitism. Two puparia from Papua New Guinea were hyperparasitised by a species of Hymenoptera, but unfortunately only larvae are available and identification is not possible.

Representative specimens are deposited in the Entomology Branch, Queensland Department of Primary Industries.

### *Parasarcophaga reposita* Lopes

#### MALE

Head golden pollinose; interfrontal area, antennae and palps dark. A row of ten to twelve frontal setae descending to level of middle of second antennal segment. One pair of reclinate orbital setae. Ocellar setae proclinate, as strong as upper frontals. Inner vertical setae very large, converging; outer verticals absent. Two rows of black setae behind eyes; remainder of hairs pale. Parafacials bare except for row of three or four setae near lower anterior corner of eye, but in some specimens a weak row of fine setae above these. Vibrissae strong, crossed; a series of fine setae above extending about half way up facial ridges. Genal hairs black. Parafrontals and interfrontals finely haired; vertex 0.17-0.19 of head width.

*Thorax* golden pollinose, with three dark vittae dorsally, median one extending on to scutellum. Spiracles dark. Three humeral setae standing in a triangle; three notopleurals; pre-alar seta present; two supra-alars; three postsutural intra-alars, anterior one small; three pre-, four postsutural dorso-centrals; three pre-, one postsutural acrostichals; scutellum with three pairs of marginal bristles, including strong, crossed, upwardly-directed apicals and with subapicals inserted far apart, distance between their bases greater than that between a subapical seta and the corresponding basal seta; three sternopleural setae (2 + 1).

*Legs* grey. Fore femur with strong dorsal (*d*), postero-dorsal (*pd*) and postero-ventral (*pv*) setal combs; tibia with two antero-dorsal (*ad*), one *pv* setae, and *ad*, *d*, *pd* (small) and *pv* (strong) apical setae. Mid femur with two distal *pd* setae, two *ad* setae and *av*, *pv* setal combs; tibia with submedian ventral seta, one strong *ad*, two *pd* setae, and *ad*, *d*, *pd*, *av* and *pv* apical setae. Hind femur with *ad*, *av* and *pv* setal combs and one distal *pd* seta; tibia with three *ad* setae and row of smaller setae between, two *pd*, one *av* setae, and *ad*, *d*, *av* and *pv* apical setae.

*Wings*. Basicosta pale, tegula dark. Basal node of  $R_{4+5}$  dorsally with row of short setae extending about half distance to *r-m*, ventrally with three or four small setae.

*Abdomen* chequered with silver pollinosity.  $T_{1+2}$  excavate to hind margin.  $T_{1+2, 3}$  without discal or marginal setae dorsally;  $T_{4, 5}$  with complete marginal rows of setae. Claspers (Figs 1, 2) strong, aedeagus (Figs 2, 3) with serrate styli. Fifth sternite (Fig. 4) deeply cleft, with marginal setae.

#### FEMALE

Differing from male as follows:

*Head*. Vertex wider, 0.25-0.28 of head width. Two pairs of proclinate orbital setae and divergent outer vertical setae present, latter about two-thirds the length of the inner verticals.

*Thorax*. Apical scutellar setae absent.

*Wings*. Dorsal setae on  $R_{4+5}$  extending further towards *r-m*.

*Abdomen*. Sternites 2-5 with strong marginal bristles. Sternites 6, 7 (Fig. 5) also with marginal bristles, sternite 7 with posterior cleft. Tergite 6+7 entire.

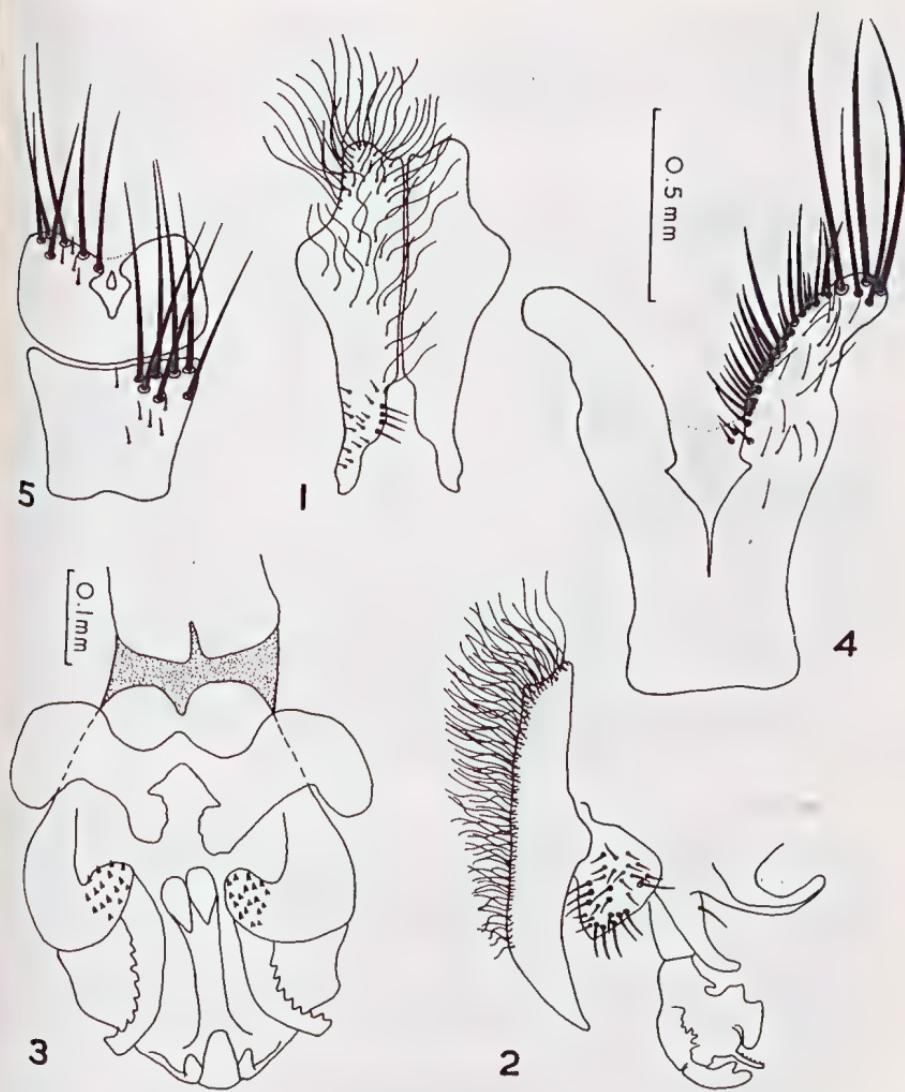
*Measurements*. Body length ♂♂ 8.0-13.0 mm, ♀♀ 9.0-12.5 mm (3♂♂, 2♀♀, Bayamatu village near Mumeng, P.N.G., 13.iii.1979, Y. D. Lubin; 8♂♂, 7♀♀, Brisbane, Q., 17.iv.1980, J. F. Grimshaw; 3♂♂, 1♀, Brisbane, Q., 29.xii.1980, J. P. Curgenven).

#### EGG

White, of muscine type (Ferrar, 1979), oval, 1.4 x 0.3 mm.

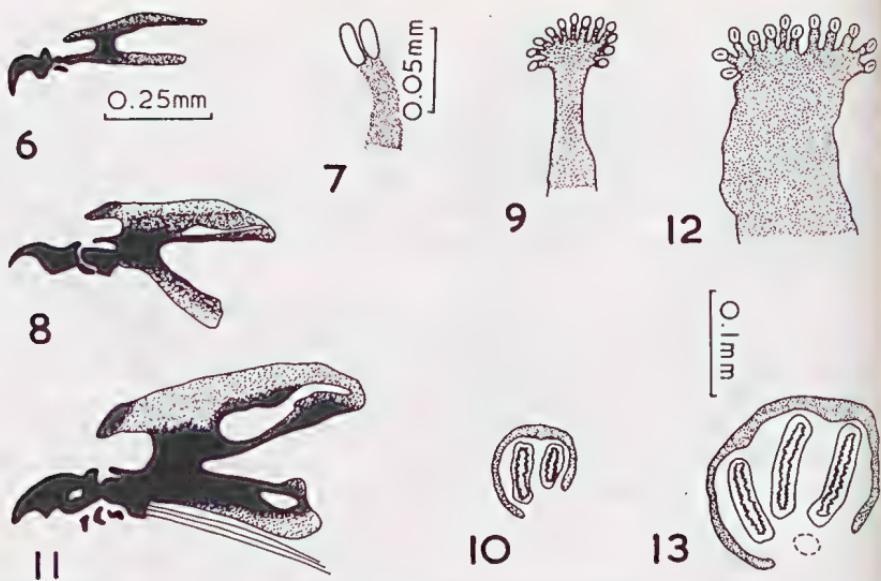
#### FIRST INSTAR LARVA

Twelve segmented, anterior sense organs on segment 1 of two types, both two segmented, one with conical second segment, other open distally



Figs 1-5. *Parasarcophaga reposita* Lopes. (1-4) ♂: (1) claspers, posterior view; (2) claspers and aedeagus, lateral view; (3) tip of aedeagus, ventral view; (4) fifth abdominal sternite, ventral view. (5) ♀ sixth and seventh abdominal sternites, ventral view. All to same scale except Fig. 3.

with a number of sensilla. Segments 2-12 (S2-12 below) with cuticular spine bands described below, typically with bands near anterior border of segments and with spines pointing posteriorly. Cephalopharyngeal skeleton (Fig. 6) with strongly curved mouth-hooks. Anterior spiracles on S2 only faintly visible under the light microscope as simple openings; posterior spiracles (Fig. 7) in pit on S12, each two oval slits and an elongate felt chamber visible through the cuticle.



Figs 6-13. *Parasarcophaga reposita* Lopes, larvae. (6-7) first instar: (6) cephalopharyngeal skeleton; (7) posterior spiracle. (8-10) second instar: (8) cephalopharyngeal skeleton; (9) anterior spiracle; (10) posterior spiracle. (11-13) third instar: (11) cephalopharyngeal skeleton; (12) anterior spiracle; (13) posterior spiracle. All lateral views except posterior spiracles, these dorsal views. Figs 6, 8, 11 and 9, 10, 12, 13 to same scales as indicated.

Spination. S2: anterior band *ca.* eight rows ventrally, anterior four slender and lightly sclerotized while posterior spines blunt and heavily sclerotized (Fig. 14); band tapers to *ca.* three rows midlaterally, then a distinct gap before continuing with *ca.* three rows mostly blunt, heavily sclerotized spines dorsally. S3, 4: anterior band *ca.* six rows short blunt spines, uniform all round body except for gap in same position as S2. S5: anterior band *ca.* six rows ventrally, but *ca.* four rows dorsally, with gap as S2. S6: anterior band *ca.* seven rows of smaller spines ventrally, tapering to *ca.* four rows below lateral midline, then a gap to a midlateral patch of spines *ca.* three rows wide and *ca.* ten spines tall; similar gap separates the dorsal part of the band of *ca.* two rows of spines. S7, 8: similar to S6, but midlateral patch and dorsal part of band progressively reduced. S9: anterior band *ca.* nine irregular rows of small spines, ventrally only. S10: band further reduced, *ca.* six rows ventrally. S11: band reduced to a rudimentary ventral patch of very small spines. S12: spines absent, but spiracular pit with fringe of fine hairs.

#### SECOND INSTAR LARVA

Twelve segmented, anterior sense organs similar to first instar. Cephalopharyngeal skeleton (Fig. 8) with narrow, curved mouth-hooks, windows in both cornua, prominent parastomal bars and ventral pharyngeal

ridges. Anterior spiracles (Fig. 9) with a simple fan of eleven or twelve rays; posterior spiracles (Fig. 10) sunk in a shallow pit, each with two slits and an incomplete peritreme. No larvae were available for a description of the cuticular spination.

### THIRD INSTAR LARVA

Twelve segmented, anterior sense organs similar to first instar. Cephalopharyngeal skeleton (Fig. 11) with stout, curved mouth-hooks with a blunt ventral spine basally, windows in both cornua, prominent parastomal bars and ventral pharyngeal ridges. Anterior spiracles (Fig. 12) with a simple fan of twelve rays; posterior spiracles (Fig. 13) in a very shallow pit without marginal lobes, each with three slits and an incomplete peritreme. Anal lobes reduced to small, rounded structures.

Spination. S2: anterior band of small, sharp spines, twelve rows ventrally tapering to *ca.* seven rows dorsally. S3, 4: anterior band *ca.* five irregular rows of widely spaced spines. S5: anterior band *ca.* four irregular rows ventrally, but only two or three rows dorsally. S6: anterior band *ca.* five irregular rows ventrally ending well below lateral midline, but with a small midlateral patch of spines, absent above. S7, 8: similar to S6, but midlateral patch smaller. S9-11: similar to S6, but midlateral patch absent. S12: anterior band consisting of a few scattered spines ventrally, but also a small patch of supra-anal spines.

*Measurements.* Length 8.5-11.0 mm, width 2.8-4.0 mm. (15 larvae, Brisbane, Q., 17.iv.1980, J. F. Grimshaw; 6 larvae, Wau, P.N.G., 24.x.1980, Y. D. Lubin).

### PUPARIUM

Reddish brown, barrel-shaped; no puparial respiratory structures visible. Larval spiracles exposed, surrounded by a groove marking the edge of rudimentary larval spiracular pit (Fig. 17). Larval anus preserved as a distinct pit.

*Measurements.* Length 7.0-9.8 mm long by 2.8-4.5 mm wide. (20 puparia, Brisbane, Q., 17.iv.1980, J. F. Grimshaw; 11 puparia, Wau, P.N.G., 21-24.x.1980, Y. D. Lubin).

### Discussion

The atypical host relationship of *P. reposita* has already been mentioned and some features of the larvae discussed below may be an adaptation to the unusual larval habitat, which is very dry in contrast to the fluid conditions experienced by carrion feeders.

Sarcophagid larvae are typically adorned with segmental bands of cuticular spines, normally arranged in distinct anterior and posterior bands (Cantrell, in press). These bands are usually better developed in first instar larvae and presumably help the larva to grip the substrate when moving in search of a suitable feeding site. Later instars show a progressive reduction in spination, probably correlated with their more sedentary habits. In the

parasitic larvae of *Blaesoxipha* Loew, spination of later instars is even further reduced (Cantrell, 1980), and similar reduction can also be seen in *P. reposita*, where posterior spine bands are completely lacking. Also, in contrast to most sarcophagids which leave the food source and pupariate in the soil, *P. reposita* pupariates within the spider egg cases.

The spine band on segment 2 of sarcophagid larvae is usually the best developed, consisting of numerous fine slender spines (Fig. 15), but in first instar *P. reposita* these are modified to a reduced number of heavy, blunt teeth (Fig. 14), the function of which is unknown. First instar *Blaesoxipha* larvae (Fig. 16), also show a reduction in the number of spines, but these are still pointed, and probably aid penetration of the host.



Figs 14-16. First instar larva, lateral view, showing spine bands: (14) *Parasarcophaga reposita* Lopes; (15) *Tayloromyia iota* (Johnston and Tiegs); (16) *Blaesoxipha similis* Cantrell.

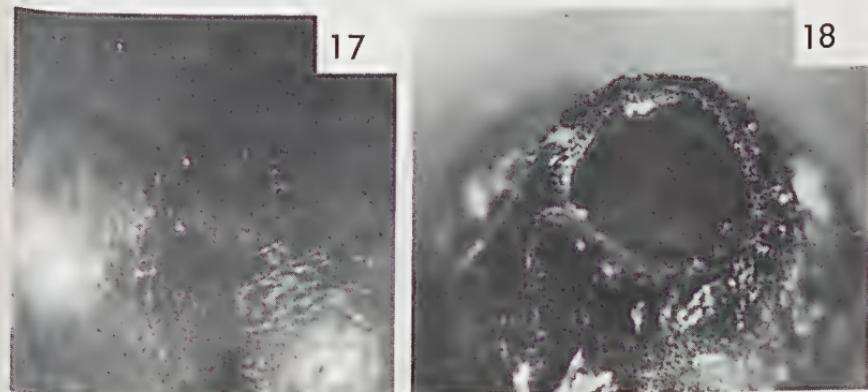
Most sarcophagid larvae have the posterior spiracles sunk in a deep caudal pit, and this is thought to be a means of keeping them free of fluid. Around the rim of the pit are usually six fleshy tubercles. However in *P. reposita*, particularly the third instar, the posterior spiracular pit is very shallow with the spiracles clearly visible, and no trace of a pit can be discerned in the puparium (Fig. 17). This is in contrast to most sarcophagids, where the spiracular pit is also visible in the puparium (Fig. 18). A similar reduction of the spiracular pit is found in *Tricharaea brevicornis* (Wiedemann) (Ferrari,

1979) although the marginal tubercles can still be discerned. These are completely lacking in *P. reposita*.

Third instar larvae of *P. reposita* can also be separated from all other known Australian species by the presence of a ventral spine on the mouth-hooks (Fig. 11).

#### Acknowledgements

I thank Mrs J. P. Curgenven, Miss J. F. Grimshaw and Dr Y. D. Lubin for providing the specimens used in this study, and Dr D. H. Colless for the loan of the holotype of *P. reposita*.



Figs 17-18. Puparium, posterior view: (17) *Parasarcophaga reposita* Lopes; (18) *Boettcherisca peregrina* (Robineau-Desvoidy).

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#### Note added in proof

Shinonaga and Barrion recently described *Pierretia litsingeri* sp.n., parasitic in the egg sacs of *Argiope catenulata* (Doleschall) in the Philippines, but no information is given on the immature stages. See "A new species of sarcophagid fly parasitic in the egg sac of the spider *Argiope catenulata* (Doleschall) in the Philippines". Kontyû 48: 537-9 (1980).

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Compiled by M. S. Moulds

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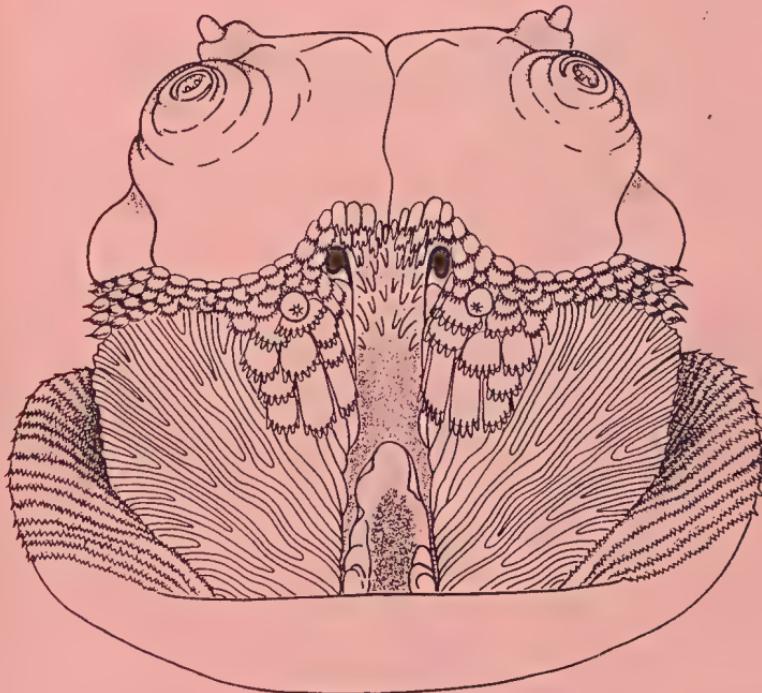
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## COLONISATION OF ANTS ON THE EXPOSED BANKS OF THE CANNING DAM RESERVOIR

By S. Woodroff and J. D. Majer

School of Biology, Western Australian Institute of Technology, Bentley, W.A. 6102

### Abstract

The plants, ants and certain epigaeic invertebrates were sampled on the banks of the Canning Dam reservoir which had become exposed as a result of several years drought.

At least 26 plant and 17 ant species had colonised the reservoir banks within 67 months of exposure. All but three ants present were also residents of the adjacent forest. Most were generalist feeders which nested in soil or subterranean dead wood. The ant species present took between about 1.5 and 67 months to colonise the banks. The species composition of ants was very similar to those recolonising nearby bauxite mined areas.

### Introduction

The south-west of Western Australia has experienced below average rainfall since 1975. As a result, the water in the reservoirs in this area is at an extremely low level. The exposed ground, which was previously inundated, is in the process of being colonised by a range of native and exotic plant species, and various invertebrate taxa are also becoming prominent. These conditions provide a natural situation for the study of species capable of colonising freshly available land.

The present study records the ants which have colonised recently exposed ground on the banks of the Canning Dam reservoir, 35 km SE of Perth and compares the species here with those colonising the nearby mined areas. Some notes are also given on the abundance of other invertebrates and plant species occurring on the reservoir banks.

Another study of invertebrate succession, with particular reference to ants, is in progress in rehabilitated bauxite mines situated at Del Park and Jarrahdale, respectively 90 and 45 km SE of Perth (Majer, 1978). Here attention is being focused on the sequence of ant species which colonise the mined areas.

#### Site description and methods

Canning Dam reservoir is situated in the northern Jarrah (*Eucalyptus marginata* Donn. ex Sm.) forest. Construction of the reservoir was commenced in 1933 and it was opened in 1940. The dam wall is 66 metres high and the sides of the reservoir usually follow the original contours of the valley. All vegetation was removed prior to flooding of the valley while topsoil and some subsoil were displaced in certain areas near the dam. In most areas the banks of the reservoir are covered in clay, silt or the original topsoil. Large granite outcrops dominate certain areas and many stumps of dead trees are present.

By inspection of the monthly water level records it was possible to determine the period of continuous exposure of sections of the surrounding bank. As a result, zones of ground along the banks were identified which had been exposed for 1.5, 5, 16, 54 and 67 months following depression of water levels. The respective zones average a linear distance of 87, 69, 55, 29 and 4 metres from the forest margin.

Ten transects, spaced at 10 m intervals, were marked out from the top of the banks to water level along both the north-west and north-east banks of the reservoir. The adjacent forest was not sampled since the ant fauna of this region is reasonably well known (J. D. Majer, unpublished data). Single pitfall traps were installed in April, 1980, at points representing the five exposure zones on each of the twenty transects. Traps consisted of Pyrex test tubes of 18 mm internal diameter and 15 cm depth and contained 10 ml of 70/30 v/v alcohol/glycerol mix. Greenslade and Greenslade (1971) have demonstrated that this preservative is non-attractive to ants although some other invertebrates may be attracted. Following a one-week settling-in period the traps were uncorked and left open for seven days. In order to provide further information on ant distribution a thorough search was made for ant nests along the banks and the time of exposure of land upon which they were found was recorded. The collections were then taken to the laboratory for sorting. With the exception of ants, the invertebrates were scored at the order or family level. Where ant species could not be assigned specific names they were coded with Australian National Insect Collection (ANIC) or Western Australian Institute of Technology Collection (J.D.M.) code numbers. The taxonomy of many Australian ant genera is not well known. Some of the species names given in this paper apply only in a very broad sense and identify what are often species complexes. Therefore, voucher specimens from this study are retained for subsequent study at the Western Australian Institute of Technology.

A 10 by 1 metre strip of ground was marked out adjacent to each pitfall trap and parallel with the water's edge. The numbers, and species, of plants and percentage cover in this area were scored. Since the plants were sparsely distributed a thorough search was made along the banks for additional species and the exposure times for collection sites were recorded.

### Results

The mean numbers of plant individuals per transect and their frequency at each exposure zone are shown in Table 1. As with the ants, they are listed in decreasing order of colonising ability. Thirteen species were recorded in the transects, all of which are native to the area. The more extensive search for additional species revealed the following plants; down to 1.5 month zone *Hypochoeris radicata* L.; down to 16 month zone *Gomopholobium marginatum* R.Br., *Dittrichia viscosa* (L.) W. Greuter, *Viminaria juncea* (Schrad. and Wendl.) Hoffmanns; down to 54 month zone *Bossiaea aquifolium* Benth., *Daviesia* sp. indet., *Grevillea bipinnatifida* R.Br., *Cryptandra* sp., and down to 67 month zone *Hakea petiolaris* Meissn., *Hovea trisperma* Benth., *Lasio-petalum floribundum* Benth., *Synaphea petiolaris* R.Br., *Mirbelia spinosa* Benth., *Scirpus* sp. With the exception of *H. radicata* (a flatweed) and *D. viscosa* (Stinkwort), all are native species.

TABLE 1

Mean number and frequency of plants growing in 20 transects situated on ground exposed for different periods of time along the bank of the Canning Dam reservoir.

Species	Mean numbers per transect					Frequency/20 transects					
	Exposure time (months)					Exposure time (months)					
	67	54	16	5	1.5		67	54	16	5	1.5
<i>Grevillea trifida</i> (R. Br.) Meissn.	0.1	0.1	0.1	0.1	0.1	6	1	2		1	
<i>Amaranthus viridis</i> L.	0.9	0.3			0.1	6	6			1	
<i>Eriostemon</i> sp.?	0.1	0.2	0.1	0.3		1	1	1		2	
<i>Kennedia prostrata</i> R. Br.			0.1	0.3			3		1		
<i>Acacia pulchella</i> R. Br.	0.1	0.1	0.1			1	2	2			
<i>Lepidosperma angustatum</i> R. Br.	0.1	0.2	0.1			2	3	1			
<i>Baeckea camphorosmae</i> Endl.	0.1		0.1			1			1		
<i>Eucalyptus calophylla</i> Lindl.	31.2	3.5				11	16				
<i>Hakea undulata</i> R. Br.	0.9	0.1				2	1				
<i>Daviesia cordata</i> Sm.			0.7					2			
<i>Daviesia horrida</i> Preiss ex Lehm.	0.5					3					
<i>Phyllanthus calycinus</i> Labill.	1.3					2					
Gen. indet.	0.1					1					

Plant cover ranged from 0% at the 1.5 month exposure zone to between 1-5% at the 67 month zone. Isolated patches of dense *E. calophylla* covered up to 30% of ground in very restricted areas of the 67 and 54 month zones.

Twelve species of ants were collected in the pitfall traps. The mean numbers of each species per trap and their frequency out of the twenty traps at each exposure zone are shown in Table 2. The ants are listed in decreasing colonisation ability. This was assessed in terms of how far down the banks they were sampled and also their abundance in traps at each zone. The asterisks on Table 2 indicate the lowest exposure zone where nests of a

particular species were found. Nests of five species were found which were not sampled in the pitfall traps. These are also shown in Table 2.

Table 3 shows the mean numbers of the other arthropods collected in pitfall traps. The values should not be used for comparison between taxa since mobility of the animal influences catch as does the fact that it may be attracted to the alcohol preservative (Greenslade and Greenslade, 1971). The counts are useful for indicating the range of taxa present on the banks and also their relative abundance levels in different exposure zones.

TABLE 2

Numbers represent mean number and frequency of ants sampled by pitfall traps situated on ground exposed for different periods of time along the bank of the Canning Dam reservoir. Asterisks indicate the lowest level where nests of a particular species were found. Five of the species were not sampled in the pitfall traps.

Species	Mean numbers per trap					Frequency per 20 traps					
	Exposure times (months)					Exposure times (months)					
	67	54	16	5	1.5		67	54	16	5	1.5
<i>Rhytidoponera inornata</i> (Crawley)	1.7	4.1	3.6	0.6	0.1*	10	11	13	4	2	
<i>Cardiocondyla nuda</i> (Mayr)	0.2	0.2	0.2	0.3		3	2	2		2	
<i>Camponotus</i> sp. J.D.M. 25	0.2	0.1		0.1	0.1	1	1		1	1	
<i>Iridomyrmex purpureus</i> (Fr. Smith)	1.0	1.0*	0.7	0.4		6	4	5	4		
<i>Rhytidoponera violacea</i> (Forel)	1.9	0.3*	0.7	0.4		10	3	3	2		
<i>Camponotus</i> sp. J.D.M. 68	1.1	0.1		0.4		7	1		1		
<i>Iridomyrmex</i> sp. 21 (ANIC)	0.6	0.4	0.1*			4	4	4	1		
<i>Brachyponera lutea</i> (Mayr)			*								
<i>Iridomyrmex</i> sp. J.D.M. 217			*								
<i>Camponotus</i> sp. J.D.M. 182	1.0	0.2				6	3				
<i>Melophorus</i> sp. 1 (ANIC)	0.3	0.1*				4	1				
<i>Polyrachis</i> sp. J.D.M. 390	0.1	0.1				2	1				
<i>Tapinoma</i> sp. J.D.M. 134			1.3					2			
<i>Monomorium</i> sp. 2 (ANIC)			*								
<i>Camponotus</i> sp. J.D.M. 285	0.1					1					
<i>Myrmecia</i> sp. J.D.M. 5	*										
<i>Iridomyrmex conifer</i> (Forel)	*										

TABLE 3  
Mean number of arthropods (excluding ants) sampled by pitfall traps situated on ground exposed for different periods of time along the bank of the Canning Dam reservoir.

Arthropod group	Mean numbers per trap				
	67	54	16	5	1.5
Arachnida -					
Scorpiones	0.05				
Opiliones	0.05				
Araneae	0.75		1.60	0.95	0.80
Acarina	0.40		1.90	1.60	0.70
					0.40
Chilopoda					0.10
Collembola	α*	α	α	α	α
Insecta -					
Dermoptera	1.65	0.85	0.30	0.70	0.40
Blattodea	0.05				
Orthoptera	10.30	6.15	5.65	4.10	0.50
Coleoptera	6.50	1.50	2.45	1.30	0.60
Diptera	0.55	0.25	0.45	0.65	0.30
Hymenoptera	0.05		0.10		0.05
Larvae	0.05	0.05	0.10	0.25	0.05

\* Abundant in traps at all exposure levels.

### Discussion

This survey has demonstrated that at least 26 plant and 17 ant species are capable of colonising the reservoir banks within 67 months of exposure.

These numbers compare with approximate species counts of 150-200 plants (D. T. Bell, pers. comm.) and 120 ants (Majer, 1980a) in the adjacent forest.

Most of the plants are represented in the adjacent forest, the two weeds being the exceptions. *Viminaria juncea* is largely confined to disturbed areas within forest such as roadsides; many of the other species are common in the post-fire succession of the Jarrah forest (Bell and Koch, 1980). The nectar, seeds and herbivores associated with the plants on the upper slopes would provide a limited food-base for certain consumers. Another important food source is the decaying tree stumps and branches, which were present all over the banks, and organic detritus which has been washed up on the shore. The abundance of dead plant matter is reflected by the preponderance of decomposers in the pitfall traps (e.g. certain Acarina and Coleoptera, Collembola and Orthoptera-Gryllidae). Although a number of these taxa may be attracted to the alcohol preservative (Greenslade and Greenslade, 1971), occurrence in traps reflected their observed general abundance in the different exposure zones. The increase in abundance of these taxa with increasing exposure time appeared to be associated with the plant material becoming more amenable to attack by decomposers.

The restriction of the larger predators, the Scorpiones and Opiliones, to the upper zones suggests that food availability is inadequate for these animals in the more recently exposed areas. Although spiders were present in the lower zones, they were all minute and hence required smaller amounts of food than the larger predators.

The occurrence of ants in pitfall traps does not necessarily indicate residence in that area since many species are capable of foraging considerable distances. Incidence of nests in a particular zone is therefore a more reliable indicator of colonising ability. Nests of six of the species were not located although their frequency in traps or their known restricted foraging ability indicated that most of them had nests on the reservoir banks. The possible exceptions are *Polyrachis* sp. J.D.M. 390 and *Camponotus* sp. J.D.M. 285 which may have foraged from the adjacent forest.

All but three of the ant species found on the reservoir banks are also present in the adjacent forest (J. D. Majer, unpublished data). The exceptions are *Cardiocondyla nuda*, which is a tramp species, *Iridomyrmex purpureus* [small purple form (Halliday, 1979)], a native species which in this part of the Jarrah forest only occurs in quarries and along roadsides, and *Polyrachis* sp. J.D.M. 390 has only previously been collected in the more open wandoo (*Eucalyptus wandoo* Blakely) woodlands near Kojonup (J. D. Majer, unpublished data).

All species found on the banks nest in soil or in subterranean dead wood. The ants are largely represented by species of *Iridomyrmex*, *Camponotus* and *Rhytidoponera*, all of which are generalist feeders. The *Iridomyrmex* and *Camponotus* species are all able to utilise live or dead invertebrates and also nectar from various sources. Both *Rhytidoponera* species collect live or dead

invertebrates and also a wide variety of seeds (Majer, 1980b). *Melophorus* sp. 1 mainly consumes seed but animal material is also taken (J. D. Majer *et al.*, unpublished results). This species was only found down to the 54 month exposure zone, below which few plants were mature enough to produce seed.

Further insight into the colonising ability of these ants may be obtained by comparing the dam ants with those colonising rehabilitated bauxite mines, surveyed between 1 and 13 years following revegetation (J. D. Majer *et al.*, unpublished results). The following ants from the present study were also found in revegetated mines; *Rhytidoponera inornata*, *R. violacea*, *C. nuda*, *Iridomyrmex conifer*, *I. purpureus* and *I. sp. 21* (ANIC) in mines revegetated two years previously; *Brachyponera lutea*, *Monomorium* sp. 2 (ANIC) and *Melophorus* sp. 1 (ANIC) in mines revegetated three years previously. None of the *Camponotus* species from the banks were found in the mines. The reason for this may be the absence of abundant dead timber for nesting in mined areas. The comparison shows that there is a large similarity between the species of ants which colonise these two types of disturbed land. Furthermore there is a reasonable concordance between the time taken by certain ants to colonise bauxite mines and the exposed banks of the dam.

A number of studies on the ecology of southwest Australian ants and the influence of disturbance on certain species have been completed or are in progress. The data from this survey will ultimately be integrated with these studies in order to provide a greater understanding of how environmental factors influence ant communities and individual species.

### Acknowledgements

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## RECORDS OF THE CARRION BEETLE *DIAMESUS OSCULANS* VIGOR (SILPHIDAE: COLEOPTERA) FROM NEW SOUTH WALES

By Geoff Williams  
C/- Post Office, Lansdowne, N.S.W. 2435.

The silphids are poorly represented in Australia where only *Ptomaphila lacrymosa* Schreib., *P. perlata* Kraatz and *Diamesus osculans* Vigor are presently known.

Though *D. osculans* is widely distributed from India through to Queensland (Britton 1970) no New South Wales records have been published and the species biology has not been described. The species, however, occurs along the N.S.W. coast where it has been collected as far south as Sydney (see Table 1).

TABLE 1

Records of *Diamesus osculans* from New South Wales. All specimens, including those collected by the author, in the Australian Museum.

Liverpool, 9.vi.1954, Mrs E. Graham.  
Sydney, 1925.

Grose R., 6.iii.1971, G. Daniels.

Kempsey, 12-13.i.1956, R. Witchard.

Bruxner Park, Coffs Harbour, 27.ii.1965, D. K. McAlpine and R. Lossin.

Iluka, 19.i.1971, D. K. McAlpine.

Huonbrook, near Mullumbimby, 27.ii.1965, D. K. McAlpine.

Rawson Falls Reserve via Comboyne, i.1981, G. and T. Williams. At "black" light positioned adjoining pasture and subtropical rainforest.

Lansdowne via Taree, ii.1981, G. and T. Williams. In association with carrion in pasture.

Maria River State Forest, approximately 11 km S of Kempsey, iii.1981, G. and T. Williams.  
At "black" light in dry sclerophyll forest regrowth.

The *D. osculans* encountered by me at Lansdowne (Table 1) were taken from calf carrion, in which three adults and two larva were occupying the "corridor" formed by the adjoining vertebral sections that comprised the backbone. Two further adults were present directly below the backbone. The adults and larvae within this "corridor" were particularly agile in moving along its length and turning within it though their body width was only slightly narrower than the space afforded. They had obviously occupied a particularly effective protective niche which was not apparently shared with any of the other numerous carrion-associated insects also present [Diptera, trogid and staphyliid beetles, and one additional silphid (*Ptomaphila* sp.)].

Individuals of *D. osculans* also emit a distinctive sound when in flight. Whereas most large Coleoptera make a low pitched drone-like buzzing when in flight *D. osculans* produces a high pitched sound of short duration more akin to those sounds produced by some Diptera, Hymenoptera and Orthoptera.

### Acknowledgements

I would like to thank Dr C. N. Smithers of the Australian Museum, Sydney, for his kindness in providing data on *D. osculans* from material in the Australian Museum, and to Mr M. S. Moulds for his comments on the draft.

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## THE IMMATURE STAGES OF *EUPLEXIA IORRHOA* (MEYRICK) (LEPIDOPTERA: NOCTUIDAE)

By L. Hill

27 Mary St, North Hobart, Tasmania 7000.

### Abstract

The immature stages of *Euplexia iorrhoea* are described and notes given on the distribution of this species.

### Introduction

*Euplexia iorrhoea* (Meyrick) is known only from Tasmania. Nothing has been recorded of its biology or immature stages. Artificial rearing of larvae and consideration of light trapping collections have provided an insight into the biology and distribution of this species.

### Methods

Three light-trapped females were placed in glass oviposition jars with stretched muslin covers, folded paper towel and a 2% sugar solution. Eggs were removed to moist filter paper in petri dishes after surface sterilizing. Larvae were reared on a modified Shorey's medium in waxed paper cups and pupae removed from the cups and placed in folded paper towel in glass jars with loosely attached lids. Pupae were moistened every few days and adults of normal appearance and size were obtained.

Photoperiods during rearing (February-July) comprised natural light plus an irregular amount of artificial light for a few hours on many nights. Temperatures during egg incubation were 18-21°C and during larval growth were 16-20°C. Rearing took place in a laboratory near sea level in Hobart and optional room heating was used to provide temperatures considerably warmer (10-16°C greater) than at the site of capture of the females, viz. nearby Mt Wellington, 1000 m. A fourth female was captured after the main study was completed and larvae reared from it using both media and various low garden plants as food. This female and its progeny were kept under a wider temperature range.

The chorion of ethanol preserved eggs was examined in lactophenol slide preparations of chorion fragments at  $\times 400$ . Measurements of ethanol preserved eggs were made using a dissecting microscope and scaled eyepiece and all drawings were prepared using a grid eyepiece.

The terminology of egg structure follows that of Salkeld (1975) but the term ribs rather than reticulation is used here to indicate solid, well defined struts lying on the chorion and often surmounting the broad vertical chorion ridges found in many noctuid eggs.

*Material examined*:- Eggs from three females and larvae and pupae from two of these. Females collected at Chalet, Mt Wellington, 1000 m, 1.ii.1979, L. Hill. Numbers 8 and 9 in Tasmanian Agriculture Dept. Entomology

Branch Collection and number 10 in Australian National Insect Collection (labels include author's numbers).

### Egg

*Description:* Table 1 gives details of size and vertical ridge number. Dome-shaped; cream when fresh, developing orangish brown equatorial band and dorsal pole after 2-3 days; alternate vertical ridges extending from outer margins of tertiary cells to circumference of smooth, flat base but remainder not extending so far dorsally; series of horizontal ridges linking vertical ridges, their junctions with latter alternating along either side of each vertical ridge; vertical ridges 6-8  $\mu\text{m}$  wide; horizontal ridges narrower; both types of ridge devoid of surmounting longitudinal ribs; aeropyle openings 5  $\mu\text{m}$  diameter, on vertical ridges at junctions with horizontal ridges, extending full length of vertical ridges; chorion of secondary, tertiary and columnar cells pitted (in slide preparations) with numerous holes *ca* 1.0  $\mu\text{m}$  diameter; chorion of ridges and primary cells not pitted; micropylar rosette 80  $\mu\text{m}$  diameter, with *ca* 15 cells; secondary and tertiary cells below level of primary cells and dorsal ends of vertical ridges i.e. micropylar rosette appearing raised.

TABLE 1  
Egg size and vertical ridge number of *E. iorrhoea*; samples drawn from three females, s.d. are means of three subsamples standard deviations

	Mean	s.d.	Range	n
Height (mm)	0.53	0.03	0.49-0.57	25
Diameter (mm)	0.81	0.02	0.77-0.85	25
Vertical ridges	21.2	0.68	18-23	38

*Comments:*— The four females laid 142, 152, 145 and 439 eggs and survived in captivity 11, 19, 5 and 9 days respectively. Eggs from the female surviving 19 days failed to develop. Eggs were oviposited singly and occasionally in pairs and triplets, cemented by the base in approximately equal numbers to the glass, muslin and paper towel surfaces. The incubation period was 5-10 days.

In slide preparations the columnar cell chorions of *Neumichtis sepultrix* (Guenée) and *Syntheta nigerrima* (Guenée) also appear pitted by numerous holes *ca* 1.0  $\mu\text{m}$  diameter. Scanning electron microscopy at  $\times 400$  of the eggs of these two species has shown the columnar cell chorion surfaces to have irregular anastomosing struts forming cavities (Hill, unpub. thesis). The vertical ridges of these two species are also devoid of surmounting longitudinal ribs. In contrast, the columnar cell chorions of *Rictonis* Nye and *Praxis* Guenée appear solid or very finely pitted in slide preparations and nearly smooth in scanning electron micrographs taken at  $\times 1000$ . The vertical ridges of these two genera are surmounted by longitudinal ribs 1.5-6.0  $\mu\text{m}$  wide and three to four times higher than wide.

**Larva**  
(Figs 1-5, 8-11)

*Description:*— Table 2 gives details of head capsule dimensions.

First instar 1.75-3.50 mm (n = 8); green without distinct markings; setae black, 0.2 mm long, on large brown plates *ca* 0.06 mm wide; prolegs short on abdominal segments 3 and 4.

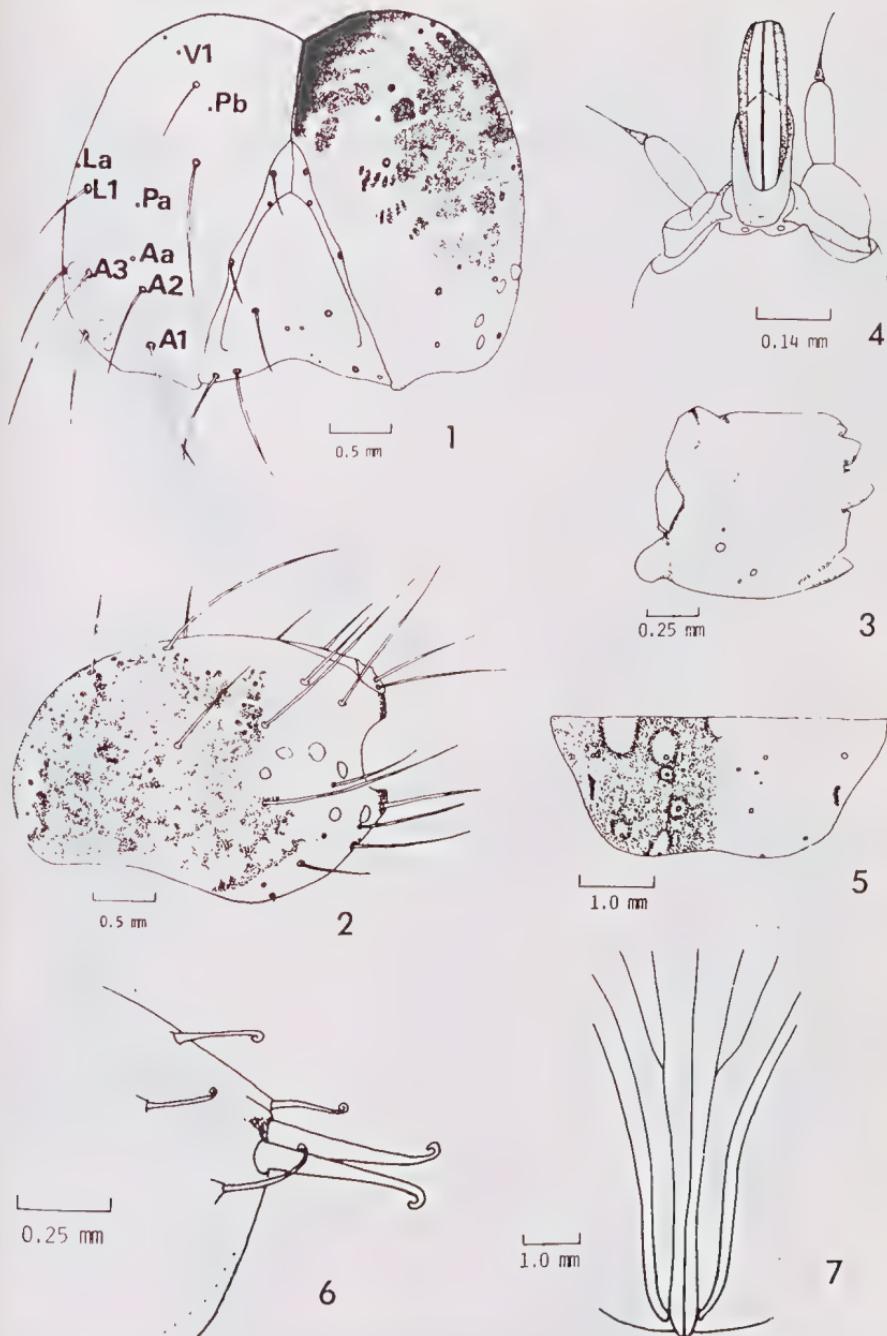
Second instar *ca* 2.5 mm (n = 1); green with white middorsal and supraspiracular longitudinal stripes, setae without white circle at bases, head markings similar to later instars, some larvae with patches of black and reddish brown pigments; setae not on plates.

Third instar 7-13 mm (n = 3); fourth *ca* 9 mm (n = 1); fifth 12.5-21.0 mm (n = 5); sixth 19-35 mm (n = 6); markings of third to sixth instars similar to seventh.

Seventh instar 30-50 mm (n = 8); with pale and dark forms (Figs 8-11), both countershaded, both greyish pink in ventral half, darker greyish pink or blackish pink in dorsal half, dark forms possessing patches of black and reddish brown pigments; conspicuous protruding orange and white circles 0.75 mm diameter at bases of D2 setae on abdominal segment 8; conspicuous series of black circles 0.70 mm diameter at bases of abdominal SD1 setae, merging into black supraspiracular band in dark forms; orange and white supraspiracular stripe limited to thoracic and anal segments; faint pale areas extending posterodorsally from SD1 setae; abdominal D1 setae in white circles 0.28 mm diameter; abdominal D2 setae in orange circles 0.38 mm diameter; abdominal L1, L2, L3 and MD1 setae in white circles 0.20 mm diameter; L1 and MD1 circles without black margins, other circles with black margins; prolegs equal, crochet formula 30: 31: 32: 33: 38, ranges 28-32: 28-33: 30-35: 31-36: 36-45 (n = 14); cuticle appearing smooth at x80. Thoracic D1 and D2 setae in white and orange circles 0.35 mm diameter with black margins; thoracic L1, L2 and L3 setae in white circles without black margins; prothoracic shield (Fig. 5) similar in colour to general dorsal surface but with five white patches across anterior margin. Head (Figs 1, 2) medium brown dorsally, pale along line of V and P setae, light brown laterally with pale areas posterior to stemmata, pale ventrally and anteriorly, black around

TABLE 2  
*E. iorrhoea* head capsule dimensions; F/Ep = length of frons / length of epicranial stem

Instar	Width (mm) mean and range	Dyars value	F/Ep mean and range	n
1	0.42 (0.41-0.43)	—	1.33 (1.11-1.64)	8
2	0.60 (0.55-0.63)	1.43	1.21 (1.07-1.42)	7
3	0.93 (0.85-1.12)	1.55	1.08 (1.00-1.20)	17
4	1.40 (1.27-1.50)	1.51	0.99 (0.91-1.09)	14
5	1.96 (1.82-2.14)	1.40	0.90 (0.80-1.09)	16
6	2.65 (2.52-2.87)	1.35	0.81 (0.72-0.91)	9
7	3.77 (3.50-4.10)	1.42	0.81 (0.73-0.94)	14



Figs 1-7. *E. iorrhoea*, last instar larva. (1) head capsule; (2) same, right lateral; (3) right mandible, lateral; (4) spinneret and labial palpi, ventral; (5) prothoracic shield; (6) cremaster spines, left lateral; (7) pupal appendages.

bases of setae, stemmata in arc of white pigment broken between stemmata 4 and 5; mandibles (Fig. 3) with medial subapical tooth on ventral ridge. spinneret subequal in length to palpi (Fig. 4) (slightly longer than palpi in earlier instars). Spiracles brown with black rims.

*Comments*:- The seventh instar larvae were large compared with ultimate instar larvae of 17 other noctuid species reared concurrently. Larval duration, from hatching to pupa formation, was 53-81 days (mean 67 days) and comparable with those of several major and minor multivoltine pest Noctuidae reared concurrently e.g. *Persectania ewingii* (Westwood) 45-55 days (mean 50 days). Larval durations of the progeny kept at wider temperature ranges and fed plants in addition to media were within the preceding range. The prepupal period lasted only a few days.

#### Pupa (Figs 6, 7)

*Description*:- Dark brown, ca 220 mm long, with a row of punctuation around the anterior margins of abdominal segments 5-7 and to a lesser extent on 4.

*Comments*:- The pupal duration was 51-83 days (mean 63 days) and longer than those of all the other species reared concurrently (including univoltine species) except for one montane early winter flying species in or near *Euplexia*. Pupal durations of the progeny kept at wider temperature ranges fell within the range given above.

#### Discussion

Adults of *E. iorrhoea* occur between December and March and are restricted to montane and higher country. Turner (1925, 1938) recorded *E. iorrhoea* adults from 420 m and 700 m on Mt Wellington near Hobart, from over 1000 m near Mt Field and at 1000 m near Cradle Mt. Adults have recently been collected at 720 m, 870 m and 1000 m on Mt Wellington being more common at the higher two sites. They have also been collected at 440 m on Red Knoll at the southern end of Lake Pedder in south-western Tasmania. The vegetation at these sites includes exposed montane heath, montane wet sclerophyll forest and subapline woodland. At 870 m on Mt Wellington adults were especially numerous (mainly males) on 6 December at a mercury vapour light and represented a peak in adult activity.

The relatively short larval duration (67 days) but long pupal duration (63 days) found in the artificial rearing probably reflect adaptations to the short warm season of a high country habitat. A pupa, found in montane wet sclerophyll forest leaf litter at 400 m on Mt Wellington on January 28, emerged in nearby sea level Hobart on February 16. The minimum egg to adult duration in the laboratory was 3.6 months and the maximum was 5.6 months. *E. iorrhoea* is capable of rapid egg and larval development given warm conditions but appears unable to greatly foreshorten the pupal duration. Other Tasmanian univoltine Noctuidae reared concurrently with *E. iorrhoea*, viz. *Peripyra sanguinipuncta* (Guenée) and *Rictonis* spp. had shorter pupal



Figs 8-11. *E. iorrhoea*, last instar larva. (8, 9) pale form; (10, 11) dark form.

durations (1 month) but long larval durations (3-5 months) in the laboratory. Several multivoltine pest species had short larval (1-2 months) and pupal (2-3 weeks) durations in concurrent rearing. These latter species are *P. ewingii*, *N. sepultrix*, *S. nigerrima*, *Diarsia intermixta* (Guenée) and *Agrotis porphyricollis* Guenée.

#### Acknowledgements

I wish to thank the Tasmanian Agricultural Department Entomology Branch for providing the rearing medium, Mr P. McQuillan for general advice, Mr E. D. Edwards for identifying an adult specimen of *E. iorrhoea* and Dr J. L. Madden for access to facilities.

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## ESTABLISHMENT OF THE LESSER WANDERER, *DANAUS CHRYSIPPUS PETILIA* (STOLL) (LEPIDOPTERA: NYMPHALIDAE) ON NORFOLK ISLAND

By B. Evans

Box 305, Norfolk Island, New South Wales 2899

On 22nd March, 1980 I noticed a specimen of *Danaus chrysippus petilia* (Stoll) (Lesser Wanderer) visiting flowers of gerberas in my garden in New Cascade Road, Norfolk Island. The identification was subsequently confirmed by the Australian Museum. Three further specimens were seen later on the same day.

On 23rd March, mating and egg laying (on Cotton Bush, *Gomphocarpus*) were observed. By the end of March four specimens had been collected and many seen in flight.

The period 22nd to 24th April, 1980 was spent on Philip Island (about 6.5 km south of Norfolk Island). On this occasion adults and larvae were seen. One adult was observed drinking from salt water.

*Danaus chrysippus* has not previously been recorded from Norfolk or Philip Islands but it is now clearly established as a breeding species. As observations on the butterflies of Norfolk Island have been continuous for some years there is little doubt that the species has been detected soon after its arrival and that establishment is very recent.

## PAROPSINE BEETLE LARVAE AS POSSIBLE POLLINATORS OF *ACACIA BAILEYANA* IN VICTORIA

By T. R. New

Dept. Zoology, La Trobe University, Bundoora, Victoria, Australia 3083

### Abstract

Larvae of *Pyrgoides hamadryas* (Stål) occur on flowers of *Acacia baileyana* around Melbourne, and may act as sporadic pollinators of this and other host species. Implications of this association are briefly discussed.

Larvae of *Pyrgoides hamadryas* (Stål) are abundant on *A. baileyana* F. von Mueller and on other bipinnate acacias around Melbourne during the flowering season and have been collected in substantial numbers every year since 1974 on the La Trobe University campus. The larvae are either pale green or bright yellow (marked with black) depending on whether they are feeding on foliage or flowers, and the coloration changes to some extent with a change of diet. This correspondence of colour suggests the probability of a regular feeding association with flowers. Examination of flowering branches of *A. baileyana* in the field showed that the larvae were both very numerous and very inconspicuous on the flowers; their colour almost perfectly matches the younger open flowers and the larvae are of an overall convex shape and address themselves closely to developing, globular flower heads.

Larvae hatched from eggs laid in the laboratory were provided with either young foliage or with flowers as a potential food. They developed on either of these foods, and day-old pupae were somewhat heavier for flower-fed larvae than from those fed on foliage alone ( $N=20$  of each; flowers  $4.151 \pm 0.569$  mg, range 3.135 - 4.960; foliage  $3.157 \pm 0.366$  mg, range 2.360 - 3.885). All these pupae gave rise to viable adults.

*Acacia* pollen was found on 37 of 40 field-collected larvae examined, and ranged from 2 to  $>100$  grains per insect. Most grains were in intersegmented folds and around setal bases and may thus have resulted from larval movement rather than direct feeding activity. Fore and mid-gut content of all these larvae consisted almost entirely of flower fragments, and uncrushed pollen grains comprised about 30 per cent of the area of randomly selected 'smears'. The faeces also contained many recognisable and unfragmented pollen grains.

Flowers of *A. baileyana* are therefore a usual and adequate food for these larvae.

Adult beetles are frequently implicated as pollinators of a wide range of flowering plants (Proctor and Yeo 1973), but larvae are generally considered not to be involved in pollination. Anthophily in Coleoptera appears to have arisen independently in several groups (Grinfeld 1975) and, although any 'advantage' in pollination by such beetles may well be negated by their consumption of flowers, it is likely that any such regular association between insects and flowers may occasionally result in pollination.

In general little specific information is available on pollinating agents of acacias. *A. baileyana* is known to be self-compatible (Newman 1934), and it is likely that *P. hamadryas*, and possibly other paropsine larvae, may play a role in pollination of this and related *Acacia* species.

### Acknowledgements

I am very grateful to Mr P. Kelly for his comments on the identity of *P. hamadryas*, and to Mrs J. M. Tenberge for her careful technical assistance.

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## BOOK REVIEWS

*Handbook of insect collecting (collection, preparation, preservation and storage)* by Courtenay Smithers. 1981. A. H. & A. W. Reed, Sydney and Wellington: 120 pp. Price: \$14.95.

In this slim volume the author has drawn on his long experience as a professional entomologist to provide "an introductory guide for those who want to make a collection of insects". He rightly emphasises the fascination and satisfaction to be had from collecting and studying insects. A simplified account of the structure and development of insects is followed by more detailed sections on naming and classification (including a synopsis of insect orders), collecting and transportation, preservation, mounting and storage, insect rearing and identification (including the use of keys and a key to the orders).

The range of preservation methods is by no means exhaustive, emphasis has been given to standard, well tried techniques and materials; no doubt specialists will find that some of their cherished procedures have been omitted. Remembering my own teenage collecting difficulties, a list of suppliers of entomological equipment would have been a welcome addition for beginners. Unfortunately, carbon tetrachloride, recommended as a killing agent (p. 43) and for degreasing insects (p. 74) is nowadays known not to be "relatively harmless to human beings". And the booklet by K. R. Norris listed under "Further reading" has passed through two greatly expanded editions (1974 and 1980) since it was first published in 1966.

The book is attractively produced, clearly written and informative, and should be of immense interest and stimulus to potential insect collectors and other naturalists.

I. F. B. COMMON

*Butterflies of Australia* by I. F. B. Common and D. F. Waterhouse. Revised edition. 1981. Angus and Robertson, Sydney & Melbourne. xiv, 682 pages, 49 pls. Price: \$39.95.

Since the first edition of this book appeared in 1972 much has been published in scientific journals and academic texts concerning Australian butterflies. In *Australian Entomological Magazine* alone, over 90 papers covering some 280 pages have appeared and these add, amongst other things, a large amount of life history data and 13 species and one subspecies to the Australian fauna. All this information is summarised in this revised edition. Many previously unpublished facts are also included. For the amateur and professional this new edition must be considered an essential reference.

The format of the book is a little different from that of the first edition. The page dimensions are slightly smaller, the text has been entirely reset in a larger type face and the contents now run to 682 pages instead of 498. Eight new plates have been added (1 colour and 7 black and white) and some minor corrections and improvements made to existing colour plates. The additional colour plate and one black and white plate feature adult butterflies representing species not illustrated in the first edition. The remaining plates show a number of larvae and pupae not previously included (5 plates) and *Eurema* species photographed under ultra violet light (1 plate).

In this second edition meticulous attention has again been paid to nomenclature. A few names have been changed and some minor corrections made.

I have two criticisms, both concerning the plates. Almost without exception the blocks of figures have been positioned high on the page leaving a disconcerting gap between the bottom figures and the caption. Particularly bad are plates 8, 9, 20, 22 and 45. I also feel that the plates should have been placed closer to their relevant text rather than spaced evenly throughout the book.

Butterfly enthusiasts are indeed fortunate to have this revised edition available. Those seriously interested in our butterflies cannot afford to be without it even if already possessing a copy of the original.

M. S. MOULDS

## ALIMENTARY TRANSPORT OF POLLEN IN A PARACOLLETTINE BEE (HYMENOPTERA: COLLETIDAE)

By Terry F. Houston

Western Australian Museum, Francis Street, Perth, W. Aust. 6000

### Abstract

Females of the bee *Leioproctus (Euryglossidia) cyanescens* (Cockerell) lack scopae and ingest pollen, carrying it in the crop. Other species of *Euryglossidia* have scopae on the hind legs and carry pollen externally (as is usual amongst Paracolletini).

### Introduction

One of the chief characteristics used to distinguish subfamilies of the Colletidae has been the presence or absence of a pollen-holding scopa in females (in this family, a set of branched setae on the hind tibiae and usually also on the hind coxae, trochanters and femora). Females of the subfamilies Colletinae, Diphaglossinae, Stenotritinae and Xeromelissinae have such scopae on which they transport pollen to their nests in a more or less dry state. However, the Hylaeinae and Euryglossinae lack scopae. Their females ingest pollen and transport it, mixed with nectar, in the crop. At the nests, the females regurgitate the food as a semifluid paste.

This paper makes known the atypical habit of an Australian colletine bee (in the tribe Paracolletini) whose females have no scopae and transport pollen internally like Euryglossinae and Hylaeinae.

*Identity.*— The species concerned is a member of the subgenus *Euryglossidia* Cockerell (in the genus *Leioproctus* Smith), a group of 21 described species badly in need of revision. Michener (1965) gives the most recent account of the group and mentions the degenerate scopa of *L. (E.) cyanescens* (Cockerell). My specimens agree with the features of *cyanescens* noted by Michener and also with most of the original description given by Cockerell (1929). However, there are small discrepancies and the name *cyanescens* is used here tentatively pending revision of the subgenus. All specimens mentioned here are in the Western Australian Museum.

### Observations

Specimens were first collected by the author on September 7th 1979, 30 km north of Bullfinch in south-western Australia; three males and five females were taken on flowers of *Acacia aciphylla* and *Thryptomene tuberculata*. Absence of the usual tibial scopae and pollen loads of females was noticed: nowhere on the hind legs or body were there sufficient plumose setae to carry adequate pollen loads. Absence of the scopa in some other groups of bees (e.g. *Thyreus*, *Inguilina* and *Coelioxys*) is associated with parasitic habits but, to date, no reports of parasitic habits in the family Colletidae have been verified. The species was next encountered on October 9th-14th 1979 at Emu Rock, 53 km east of Hyden, W.A. Females were

abundant at flowers of *Muehlenbeckia adpressa* and occasional on flowers of *Acacia ligulata*. Dozens of females were closely inspected but none had any obvious pollen load. However, those on *Acacia* flowers could be clearly seen obtaining pollen: with jaws held wide apart, they walked through the stamens and raked the anthers towards the mouth. Several females collected at the flowers were dissected and proved to have crops distended with pollen. There can be no doubt that this species gathers pollen and transports it internally.

At least nine other species of *Euryglossidia* are represented in the collection of the Western Australian Museum and females of all of them have at least sparse tibial scopae composed of plumose setae. The hind coxae, trochanters and femora, and the metasomal sterna also bear branched setae. One or more females of each species has conspicuous pollen loads on these setae. There is marked variation amongst species in the degree of development of the scopa. As Michener (1965) noted, compared with other Paracolletini, *Euryglossidia* typically have a sparse scopa, but one relatively large unidentified species in the Western Australian Museum has quite a dense scopa of highly plumose setae extending over most of the hind legs and metasomal sterna. Apart from this species and *cyanescens*, all of the *Euryglossidia* specimens for which I have plant data have been collected at flowers of *Hakea* and *Grevillea*. Microscopic examination reveals that the pollen of these plants is relatively coarse and the sparse scopae of the bees are presumably adapted to holding the large grains.

### Discussion

The evidence presented above indicates that females of *L. cyanescens* gather pollen for nest provisioning and are not parasitic as their lack of scopae might suggest.

It is generally considered that the most primitive bees had scopae and thus the absence of scopae is a derived condition. If the Hylaeinae and Euryglossinae represent independent losses of scopae (as I believe is probable) then *L. cyanescens* represents the third known change from scopal to alimentary transport of pollen.

Alimentary transport of pollen must bring with it certain advantages: females are saved the effort of manipulating pollen onto the scopa at flowers and off the scopa in the nests and combining nectar with it to form the larval provisions. However, it is most unlikely that such a change could occur without some preliminary changes in the bees' environment to act as a catalyst. As previously noted, many species of *Euryglossidia* have sparse scopae seemingly correlated with their preference for *Grevillea* and *Hakea* pollen. Thorp (1979) gives evidence of an inverse relationship between scopal density and size of pollen grains carried by other groups of bees. Thus, *Euryglossidia* with sparse scopae are probably ill-equipped to carry fine-grained pollen externally and, should their usual food plants become unavailable, their survival would depend on utilising coarse-grained pollen from other

plants or developing a new means of transporting finer-grained pollens. Perhaps the ancestor of *cyanescens* was a *Grevillea*- or *Hakea*-specialist that faced this problem and overcame it by the latter means. *L. cyanescens* has been observed to feed at flowers of three unrelated families (Myrtaceae, Mimosaceae and Polygonaceae) and is thus clearly a polylectic species. Its habit of ingesting pollen means that grain size is not a limiting factor in its choice of food plants.

#### Acknowledgements

Identifications of food plants were provided by Mr N. S. Lander, Western Australian Herbarium, Department of Agriculture, Perth.

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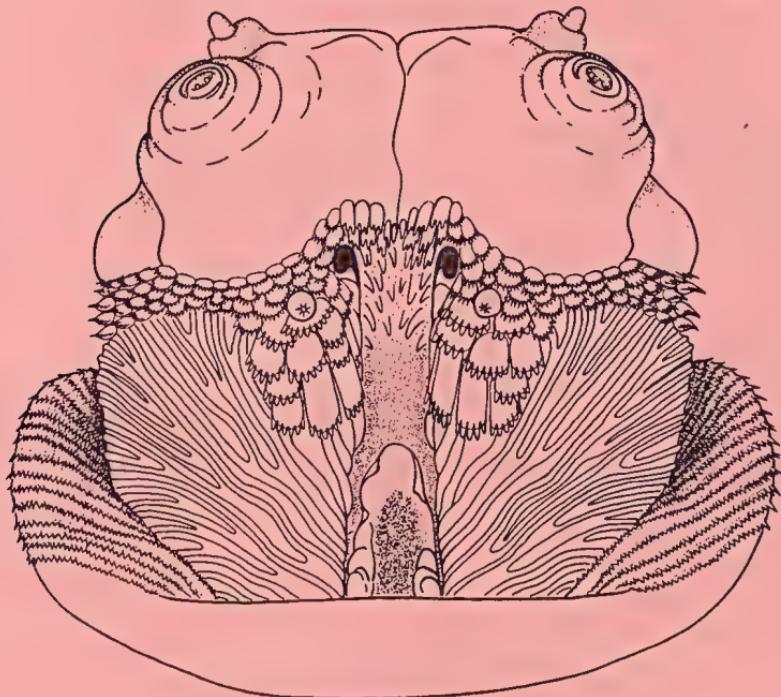
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Shows the face of the larva, *Tapeigaster annulipes* Macquart (Diptera: Heleomyzidae). The genus *Tapeigaster* is endemic to Australia, where it is widely distributed through temperate regions. The larvae of *Tapeigaster* are known to live in various kinds of fungi.

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# Australian Entomological Magazine

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## THE FAUNA OF WATER-FILLED TREE HOLES IN BOX FOREST IN SOUTH-EAST QUEENSLAND

By R. L. Kitching and C. Callaghan

School of Australian Environmental Studies, Griffith University,  
Nathan, Queensland, 4111.

### Abstract

Samples of detritus from a series of water-filled tree holes in box forest in south-east Queensland have been examined and the species encountered are discussed. Altogether nine "dendrolimnetobiotic" species are recorded: a chironomid, a ceratopogonid, two species of culicid, an helodid, three species of mite and a frog. All species spend their immature life in tree holes and, in addition, adult mites and, on one occasion, frogs were encountered. The trophic relations of the species concerned are discussed and are placed in context of work done elsewhere.

### Introduction

Water-filled tree holes are a common component of moist forest ecosystems throughout the world. Everywhere that they have been studied these habitats have been shown to contain species of insects and other animals which in most instances occur nowhere else. These organisms have been designated "dendrolimnetobionts" by some authors (Rohnert, 1950; Kitching, 1971).

Water-filled tree holes occur in many Australian ecosystems from tropical forests to urban gardens but achieve semi-permanent status only in moist coastal forests. Although a variety of culicids and ceratopogonids have been recorded from these water bodies (Dyce and Murray, 1966, 1967; Hamlyn-Harris, 1933; Kettle and Elson, 1976; Lee and Reye, 1953; Marks, 1947; Reye, 1964) no systematic study of the whole community of macro-organisms has been carried out in Australia. Some such studies have been made elsewhere in the world and these are reviewed by Thienemann (1934), Kitching (1971) and Maguire (1971).

This paper presents a preliminary account of the results of such a survey together with some notes on the physico-chemical nature of the habitat. A

monthly survey designed to shed light on the population dynamics of the animals concerned is in progress.

### Study site and methods

Water-filled tree holes in the buttress roots of brush box (*Tristania conferta* R.Br.) and strangler fig (*Ficus* spp) were selected for study. An area of relatively undisturbed forest in the Lamington National Park (grid reference P14 on Northern Sheet; Queensland Department of Forestry, Edition 1, Lamington, 1: 25,000, 1975) was visited on a number of occasions and small samples of water and detritus removed from thirteen holes. A number of other sites were visited less regularly. Each of the thirteen regularly visited sites is lined with bark and has contained detritus and free-water throughout the period of observation (July, 1979 to August, 1980).

Water samples were removed using a plastic vial and detritus samples collected by hand or using a spoon. Samples were, later, washed through a series of sieves and the sludge remaining on the finest of these (355  $\mu\text{m}$ ) was washed into petri dishes and examined using a binocular microscope.

Insect larvae from the samples were sorted and reared to adulthood so that accurate identifications could be made. In addition, some observations on the behaviour of living larvae kept in petri dishes were made in order to determine the trophic relationships among members of the community.

In addition to these biological observations, measurements of the dimensions of the holes and their height from the ground were made as were records of the pH, conductivity and oxygen content of the water contained in them.

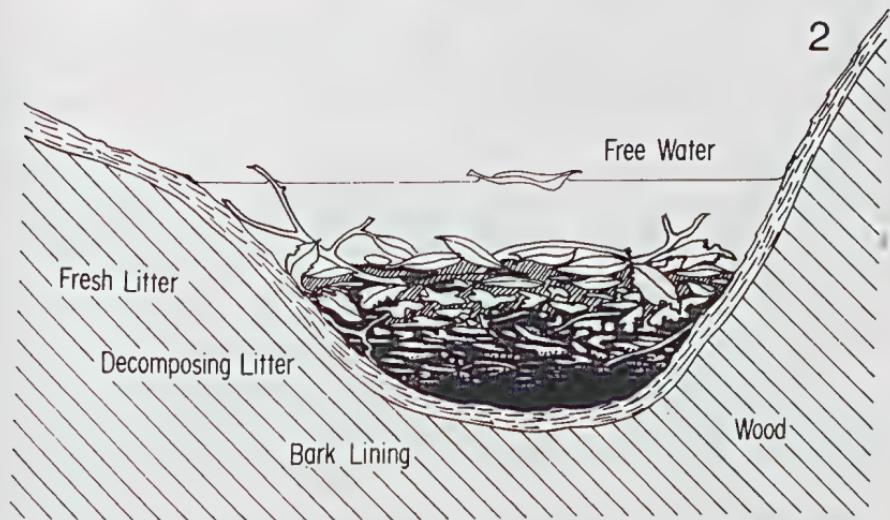
### Results

#### The physical and chemical environment

Of the 20 holes sampled, 17 were from box trees and 3 from figs. The fauna in the samples from the two species of tree did not differ significantly.

The maximum diameters of the holes studied varied from 10-70 cm with a mean of 31.1 (SE = 3.59) and the minimum diameters had a range from 8-27 cm, with a mean of 15.3 (SE = 1.56). If we make the simplifying assumption that the surfaces of the holes were elliptical in shape, this gives us a range of surface areas from 78-1429  $\text{cm}^2$  about a mean of 422  $\text{cm}^2$  (SE = 99.24). The depths of the holes sampled ranged from 3-50 cm with a mean value of 16.3 cm (SE = 3.16) and the lips of the holes were from 0-150 cm above the nearest soil level (mean 34.3, SE = 8.72).

The chemical measurements were made on water samples from only nine holes and, therefore, their preliminary nature is stressed; nevertheless, they do provide an indication of the limnological conditions experienced by the fauna. The pH recorded spanned a range from 5.1-7.1 with a mean of 5.9 (SE = 0.23); the conductivity, a range of 143-288  $\mu\text{s cm}^{-1}$  at 25°C with a mean of 226.5 (SE = 75.5); and, the level of dissolved oxygen, a range of 10-55% saturation about a mean of 30.2 (SE = 5.24).



Figs 1, 2. Water-filled tree holes: (1) photograph of a water-filled tree hole in the root buttress of a box tree; (2) schematic cross-section through a water-filled tree hole showing layering of the detritus it contains.

Both the physical and chemical data point up the considerable variability in the nature of the tree hole habitat that has been remarked upon elsewhere (Kitching, 1969).

Figures 1 and 2 illustrate the tree hole habitat both photographically and schematically. Virtually all of the energy input to the tree hole system is through the entry of plant or animal detritus although strands of a

filamentous algae were noted at one site. Some input of energy in run-off from the surface of the tree during rain is also likely. The eggs of the animals living in the holes represent a further, minor, energetic input.

### The fauna

In all we found eight species of invertebrates and one vertebrate which can usefully be termed dendrolimnetobionts. These were two culicine mosquitoes, a chironomid midge, a ceratopogonid midge, an helodid beetle, three species of aquatic mite and a leptodactylid frog. Water-filled tree holes represent the larval medium for all of these nine with adults of the mites and, occasionally, the frog sharing the habitat. A variety of other insect larvae were encountered in the litter from damp holes (that is, those with no layer of free water) but these cannot be ascribed to a specialised aquatic fauna comparable with those studied elsewhere.

Of the nine species, four have been described previously, one is undescribed but represented by labelled specimens in a recognised collection, and four are in process of separate description, one of them representing a new genus (see below).

#### 1. *Anatopynia pennipes* Freeman, 1961 (Diptera: Chironomidae: Tanypodinae)

Both larvae and pupae of this midge occurred in our samples. They were present in all 13 sites visited regularly with densities which ranged from 9.5 - 310  $l^{-1}$ .

The species was described by Freeman (1961) from three adults collected by Bancroft at Burpengary, Queensland. The adult midges are highly distinctive having a broadly-banded wing pattern and "banded and thickly haired legs" among other characteristics. The larva is red in colour and characterised (in the tree-hole fauna) by its possession of prothoracic and terminal pseudopods and paired bunches of setae at its posterior end.

The general facies of the larva correspond closely with that illustrated by Bryce and Hobart (1972) as typical of the subfamily. Tanypodinae in general are predatory in their larval stages and, according to Bryce and Hobart, prey "on small invertebrates including other chironomid larvae". We exposed living larvae of *Culicoides angularis*, *Prionocyphon* and mosquitoes (see below for specific accounts) to living larvae of *A. pennipes* in petri dishes and observed them regularly. The chironomids frequently attached themselves by their anal pseudopods to helodid larvae and attacked the larvae with their mandibles. Attacks on mosquito larvae were noted, also, but no interaction except mutual aversion when in physical contact, was observed between chironomid and ceratopogonid. The relative abundances of the helodids, mosquitoes and the chironomids observed in our samples strongly suggest these are the principal predator-prey interactions in the tree-hole system. The occurrence of a tanypodine chironomid in these sites is somewhat at odds with records from elsewhere in the world where saprophagous

orthocladiines, notably species of *Metriocnemus*, have comprised the chironomid component (Kitching, 1972a; Snow, 1958).

2. *Culicoides angularis* Lee and Reye, 1953 (Diptera: Ceratopogonidae: Culicoidinae)

Again, both larvae and pupae of this species occur in water-filled tree holes. The species occurred in 12 of the 13 sites examined closely, with densities from 6.7-251  $l^{-1}$ .

Lee and Reye (1953) described the species from Mittagong, N.S.W., from adults bred from larvae collected in a "rock pool". They also refer to other specimens from Mt. Glorious, Queensland and Cooranbong, N.S.W., all from water-filled tree holes. The Mt. Glorious locality is referred to again by Reye (1964) who describes the species there as "rare". The adult is distinguished by its large size and the pale spot in cell  $M_4$  of the wing. The larva is figured by Kettle and Elson (1976) and has a characteristic vermiform shape with distinctive posterior filaments. Kettle and Elson (1976) record larvae of this species as being predatory and observed them feeding on free-living nematodes. Observations elsewhere in the world strongly suggest that they may prey on mosquito and other larvae under natural conditions.

This species is one of two ceratopogonines described from tree holes in Australia, the other being *C. mackerrasi* Lee and Reye; however, it is the only one recorded from moist, closed forest, the other having been found in holes in eucalypts and a species of *Acacia* (Dyce and Murray, 1966, 1967).

Tree-hole ceratopogonines recorded elsewhere have been species of *Dasyhelea* for the most part (Kitching, 1972b; Rohnert, 1950), although Kremer (1965) records several species of *Culicoides* from tree holes in the old world, principally Africa.

3. *Aedes (Finlaya) candidoscutellum* Marks, 1947 (Diptera: Culicidae)

This and the following species of mosquito have their larval and pupal stadia in water-filled tree holes. *Ae. candidoscutellum* was described by Marks (1947) from adults bred from larvae taken in tree holes in Queensland, New South Wales and New Guinea although the type specimens selected were from Binna Burra, Lamington National Park, a few kilometres from our study site.

The species occurred in 8 of 28 samples with densities ranging from 2.3-9.2  $l^{-1}$ . The larvae are presumed to be grazers and/or suspension feeders, exploiting the smallest detrital particles and the micro-organisms associated with them.

4. *Aedes (Finlaya)* Marks, Species 22 (Diptera: Culicidae)

Dr E. M. Marks identified this material as belonging to an unnamed species known to her and designated "Marks: Species 22" in the University of Queensland collection housed at the Queensland Institute of Medical Research, Herston, Brisbane. The species is allied to *Aedes quasirubithorax* (Theobald). The frequency of occurrence of this species was much the same

as the preceding one but with densities ranging from  $2.3-56.7\ l^{-1}$ . This species too, presumably, is a grazer and suspension feeder as a larva.

#### 5. *Prionocyphon* sp., ANIC Accession Designation "KIT1" (Coleoptera: Helodidae)

This species was identified by Dr J. F. Lawrence, CSIRO, as an undescribed species belonging to the genus *Prionocyphon*. In appearance it resembles closely tree-hole beetles of the same genus recorded in Europe (Benick, 1924; Kitching, 1971) and North America (Snow, 1958; Petersen, 1953). The larvae (and eggs presumably) occur in water-filled tree holes but the final instar larvae leave their aquatic milieu to pupate elsewhere. Benick (1924) says (in translation): "When the time for pupation comes the larvae . . . climb up to the drier part and pupate there. In nature they are found in the upper part of the hole space". He was referring to the European *Prionocyphon serricornis* but we have observed similar behaviour in the species we encountered. We found pupae in dry leaf litter associated with the water filled portions of some holes, and, subsequently, reared out adult beetles.

The larvae are saprophagous, grazing the detrital fragments. This species occurred in high densities in all sites examined with densities ranging from  $50-1665\ l^{-1}$ .

A separate description of the species is being prepared by Lawrence and Kitching and will be published in due course.

#### 6. *Arrhenurus* sp. (Acarina: Arrhenuridae)

A species of free-swimming, red water mite identified as belonging to the cosmopolitan genus *Arrhenurus*, by Dr B. M. O'Connor (Cornell University), occurred in low numbers in a proportion of the tree holes sampled. This is the first record of the genus in such habitats.

The species occurred in 4 of the 13 holes examined regularly with densities ranging from  $6.1-48\ l^{-1}$ .

Species of *Arrhenurus* are predators recorded from other freshwater habitats preying on small organisms or parasitic upon larger ones (Williams, 1980). The relative size, abundance and free-swimming habit of this species suggests that early instar insect larvae may be the most likely prey in the tree holes we studied.

#### 7. *Cheiroseius* sp. (Acarina: Ascidae)

The rarest of the species of mite encountered in our samples, in fact found only once, belong to an undescribed species of ascid ascribed by Dr O'Connor to the genus *Cheiroseius*. They are crawlers living, presumably, in the detritus layer where the most likely prey species, again based on considerations of size and relative abundance are of a third type of mite belonging to the family Hyadesiidae.

#### 8. *Hyadesiid* sp. (Acarina: Hyadesiidae)

A species (or possibly two closely related species) belonging to an undescribed genus of the small family Hyadesiidae, was the commonest sort

of mite found in our samples (occurring in 7 of 13 sites with densities ranging from  $7-88 l^{-1}$ ).

These mites occur in the detritus layer of the tree holes and, on the basis of information on other members of the family elsewhere, are considered to be saprophages exploiting the small particle component of the resource.

This genus will be described in our course by O'Connor and Kitching.

#### 9. *Lechriodus fletcheri* (Boulenger) (Amphibia: Anura: Leptodactylidae)

In our spring samples, which followed a period of heavy rain, large numbers of eggs and larvae of this species of frog were present. It may be inappropriate to consider this species truly dendrolimnetobiontic as both Moore (1961) and Watson and Martin (1973) record it from a variety of ephemeral habitats in rain forests in eastern Australia and New Guinea. However, we include it because, at one time at least, it was the dominant element of the fauna as indicated by our samples.

The tadpoles, which were identified by Mr Glen Ingram, Queensland Museum, are distinguished by having the "anus on the right; terminal mouth . . . and the fact that the posterior part of the body forms a right angle with the tail" (Moore, 1961). They have the bluntly rounded tail of a bottom feeder and are known to be cannibalistic, feeding on eggs and smaller tadpoles. Presumably they also prey on the insect larvae which co-occur with them in the water-filled tree holes. On a single occasion we also found an adult of this species in a tree hole.

No frogs are recorded from temperate tree holes but other species have been recorded from other plant-held waters (e.g. Picado, 1913; Laessle, 1961).

#### Discussion

The restricted nature of the tree-hole fauna shown up by our studies parallels the situation observed elsewhere in the world. This restricted diversity no doubt reflects the extreme physical and chemical circumstances which they present to their inhabitants. Not only does water level change in response to local factors but oxygen levels, in particular, are particularly low, possibly reflecting a high biological oxygen demand generated by the high level of micro-organismic activity in the decaying detritus. To cope with low oxygen tension special respiratory adaptations such as the anal gills of the helodid larvae and the siphons of the culicid larvae are present. The redness of the chironomid larvae, however, is due more to material sequestered from prey animals than to respiratory haemoglobin such as is present in some non-tanypodine chironomid larvae (Bryce and Hobart, 1972).

Our observations of nine species of animal from water-filled tree holes, although including several new records, does not, of course, represent the full range of tree-hole animals in Australia. A wide variety of mosquitoes has been recorded from water-filled tree holes and these are largely summarised by Dobrotworsky (1965). Several of these records are of generalist species in the sense that they also occur in other aquatic habitats. Of those restricted

to tree holes most are of the subgenus *Finlaya* of *Aedes* or of the genus *Tripteroides*, one species of which (*atripes*) is widely distributed in Eastern Australia. Dr E. N. Marks (pers. comm.) suggests that the genus may favour very small cavities, below the size of those we examined. Among other dendrolimnetobionts of particular interest is the record of Watson and Dyce (1978) who found nymphs of the megapodagrionid damselfly, *Podopteryx selysi*, in tree holes in northern Queensland, paralleling records of Corbet (1962) and others from tropical south-east Asia.

The trophic relationships that we propose from our studies are summarised in Fig. 3 where firm relationships are indicated by solid lines and putative ones by broken lines. Basically, we recorded four species of primary saprophage (the helodid, culicids and hyadesiid) and five species of predator (chironomid, ceratopogonid, arrhenurid, ascid and leptodactylid). It seems likely that the saprophages partition the basic detritus resource probably on the basis of particle size with the culicids and the arrhenurid dealing with very fine particulate matter and the helodids feeding on more coarsely divided material. The predators seem, from what little information we have, to be catholic in their tastes.

The food web which can be imputed from these results is more complex than that recorded from similar situations elsewhere. Kitching (1971) recorded no predators from British tree holes and North American studies such as that of Snow (1958) record a single predator, mosquito larvae of

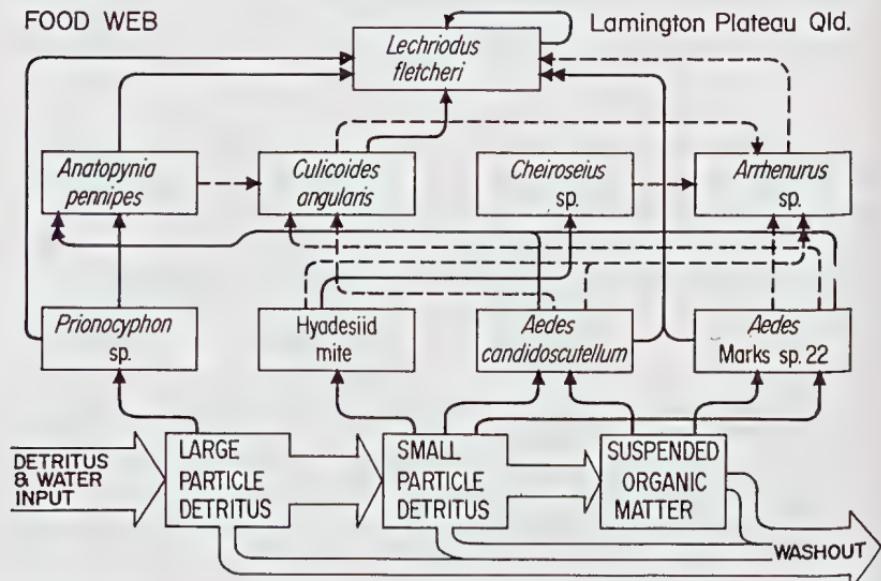


Fig. 3. Proposed food web for water-filled tree holes in south-east Queensland box forest based upon results of the present study. Solid lines indicate firm, and broken lines putative, relationships. In each case the head of the arrow indicates the consumer species.

the genus *Toxorhynchites*. Presumably the differences observed among these results reflects a response at the community level to the harshness of the environment and/or the quantity and quality of energy entering the system as detritus, acting through the conversion efficiencies of the species concerned. Further work is in progress on this aspect of the tree-hole community.

One of the principle complicating features of the Queensland food-web is the array of mites it contains. Mites are an endemic part of the tree-hole fauna in North America and, indeed, Fashing (1973, 1974) recorded both anoelid and acarid mites from such sites erecting a new sub-family, the Naiadacarinae, for his acarids. One other genus of the Hyadesiidae, *Algophagus*, is recorded from North American tree holes (B. M. O'Connor, pers. comm.). Mites occurring in scattered habitats such as water-filled tree holes must adopt parasitic or phoretic habits in order to move, as larvae, between sites. The host or transporting agents for other mites related to those encountered in this study, are known to be midges or mosquitoes to which the mites attach on emergence of the adult insect. In spite of extensive study, no mites have been recorded from European tree holes although sites in the south of that region await close examination.

Water-filled tree holes are just one of a wider class of plant-held waters usually referred to as phytotelmata. Other examples of such habitats are frequent in Australia but their faunas are largely unstudied. Among very few records is that of Dobrotworsky (1966) of *Aedes dobrotworskyi* Marks from water held in the leaf axils of swordgrass, *Gahnia* spp., and of Erickson (1968) of "the larvae of various mosquitoes and flies . . . and a very occasional tadpole" from *Nepenthes* pitchers and "slender, transparent larvae" from *Cephalotus* pitchers. Phytotelmata in leaf axils and stems of living plants and in fallen leaves and husks are common periodically in areas as different as rain forests and suburban gardens (especially where bromeliads are grown) and are deserving of further study.

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## THE CULTURE OF THE GREY CLUSTER BUG, *NYSIUS CLEVELANDENSIS* EVANS UNDER LABORATORY CONDITIONS

By Jiraporn Vattanakul\* and H. A. Rose

Dept. Plant Pathology & Agricultural Entomology, University of Sydney, N.S.W. 2006

### Abstract

*Nysius clevelandensis* Evans was cultured under laboratory conditions by feeding nymphs and adults on whole sunflower seeds. The total period from egg to adult was 33 days at  $25 \pm 2^\circ\text{C}$  and each female laid an average of 95 eggs.

### Introduction

*Nysius clevelandensis* Evans is one of three pest species of *Nysius* occurring in Australia, the other two being *N. turneri* Evans and *N. vinitor* Bergroth. *N. turneri* is restricted to Tasmania while *N. vinitor* (the Rutherglen bug) occurs in all states and *N. clevelandensis* in all states except Tasmania (Evans, 1936; Woodward, 1964). In general, *N. clevelandensis* is adapted to wet tropical and subtropical conditions, whereas *N. vinitor* can better withstand extremes of temperature and lower humidity (Woodward, 1964). At present, research in this field has concentrated mainly on *N. vinitor* (e.g. Kehat and Wyndham, 1972a, 1972b, 1973). *N. clevelandensis*, despite its wide distribution and its predominance in many areas has received scant attention. This paper concerns some aspects of the biology of *N. clevelandensis* under laboratory conditions.

### Materials and methods

Nymphs and adults of *N. clevelandensis* were collected from fleabane (*Erigeron* sp.) at Camden, New South Wales. Studies were undertaken in a room held at  $25 \pm 2^\circ\text{C}$  with variable lighting and relative humidity.

To determine a satisfactory culturing technique, trials similar to those of Attia and Elshafie (1973) for *N. vinitor* were conducted. Firstly, adults were placed on young sunflower plants inside a wire gauze cage 25 x 36 cm. Compacted cotton wool rolls on sticks were provided as oviposition sites. Secondly, adults and nymphs were fed on *Erigeron* sp. immersed in a flask of water. The flask was enclosed in a cylindrical perspex container 10 x 25 cm. The *Erigeron* was changed every second week. Two compacted cotton wool rolls inserted through holes in the plastic lid served as watering and oviposition sites. Thirdly, nymphs and adults were placed in cylindrical perspex containers, 4 x 6 cm, and fed whole and crushed seeds of soybean and sunflower. The screw-on lid of each container was fitted with fine stainless steel gauze. Cotton wool rolls again served as oviposition and watering sites, water being supplied every second day.

To study the life history, copulating bugs were transferred to 4 x 6 cm containers utilizing the same conditions as described immediately above and fed whole sunflower seeds. Eggs were collected and the duration of all life stages was noted. Records were taken daily.

\* Present address: Applied Scientific Research, Corporation of Thailand, Banghen, Bangkok 9, Thailand.

### Results and discussion

Culture methods using sunflower plants or *Erigeron* were unsatisfactory. With both methods, mortality of adults was high. Feeding the bugs on soybean seeds, either whole or crushed, was unsatisfactory because nymphal mortality was high. Whole seeds of sunflowers which were replaced twice weekly, however, were found quite satisfactory as mortality of both nymphs and adults were low. Occasionally, significant mortality was observed in second instar individuals. These nymphs, much more active than first instar nymphs, died in droplets of condensed water when excess water was supplied. To avoid mortality, therefore, the amount of water given was reduced to a minimum. This method was used in the life history studies and differs from the methods for *N. vinitor* used by Attia and Elshafie (1973) and Kehat and Wyndham (1972a) utilizing crushed sunflower seeds.

The duration of each stage from egg to adult (10 observations of each stage) is given in Table 1. The total period from egg to adult is 33 days. This compares with 29 days for *N. vinitor* at the same temperature (Kehat and Wyndham, 1972a).

Both males and females are polygamous and the egg laying period extends from 14-20 days after which the female soon dies. The numbers of eggs produced ranged from 80-150 with a mean of 95 (24 observations). This was much lower than *N. vinitor* which laid 578 eggs at 25°C (Kehat and Wyndham, 1972a).

TABLE 1. Duration of life stages of *Nysius clevelandensis* under laboratory conditions at  $25 \pm 2^\circ\text{C}$ .

Developmental stage	Mean duration (days)
Egg	7.0
Larval insta <sub>1</sub>	6.5
II	4.5
III	4.5
IV	4.5
V	6.0
Preoviposition period	5.5

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## INTERACTION OF ANTS, PREDATORS AND THE SCALE INSECT, *PULVINARIELLA MESEMBRYANTHEMI*, ON *CARPOBROTUS EDULIS*, AN EXOTIC PLANT NATURALIZED IN WESTERN AUSTRALIA

By Leanne Collins and John K. Scott\*

Department of Zoology, University of Western Australia, Nedlands 6009

### Abstract

The scale insect *Pulvinariella mesembryanthemi* is host specific to the succulent *Carpobrotus edulis*, is tended by a range of ant species and is eaten by a species of coccinellid beetle. The host plant, scale and predators are exotic to Western Australia but the ants are native. Compared with control samples, more scale insects died when ants were removed and this appeared to be due to sooty mould infestation. The removal of predators had little effect on scale survivorship. For all treatments some scale survived to contribute offspring to the next generation. Independence from ants would allow this scale to colonize new areas but the formation of large populations of scale probably depends upon the presence of ants.

### Introduction

Scale insects are well known for their ability to invade new habitats, particularly agricultural crops, and have been investigated mostly because of the harm they cause (Elton 1958; Miller and Kosztarab 1979). Scales are obligatory plant feeders, commonly forming mutualistic associations with ants (Way 1963) and are often eaten by coccinellid beetles (Hodek 1973). Obviously the complexity of the relationship between scales, host-plants, ants and predators will affect the ability of a scale to invade new habitats. In this paper we describe the interaction between a scale, host plant and a predator of the scale that have been introduced to Western Australia and native species of ant.

The succulent *Carpobrotus edulis* (L.) (Aizoaceae) is a native of South Africa but has been known from Western Australia since 1842 (Blake 1969) and is now naturalized in many coastal areas. The plant has a prostrate habit with fleshy leaves on branches which run along the ground. At the Marsupial Breeding Station, near Jandakot (32°10'S; 115°15'E), *C. edulis* is infested with the scale insect, *Pulvinariella mesembryanthemi* (Vallot) (Homoptera: Coccidae). The scale is probably host specific to *C. edulis* and appears to have migrated with the plant around the world. The scale is eaten by adults and larvae of *Cryptolaemus montrouzieri* Muls. (Coccinellidae), a species which was first introduced to Western Australia from eastern Australia in 1902 to control *Pseudococcus* species (Jenkins 1948). As far as known the ants found with the scales are native to Western Australia (J. D. Majer, pers. comm.).

In this paper we examine two aspects of the scales' population biology. Firstly, are ants necessary for the survival of the scale and secondly, what effect do the predators have on the population?

\*Present address: Ent. Branch, Dept. of Agriculture, Jarrah Rd, S. Perth, W.A. 6151.

### Species biology

The scale, *P. mesembryanthemi*, is known from a species of *Carpobrotus* from France (Pesson 1941) and more specifically from *C. edulis* in Argentina (Quintana 1956) and South Africa (Morrison and Rank 1957, p. 172; Peringuey 1892). The plant is distributed throughout southern Australia, southern Europe, California and South Africa (Blake 1969).

At the study site we examined the scales at irregular intervals between March 1979 and May 1980 and made the following observations. The scale had three or four generations. The first instar scale moved rapidly over all plant surfaces and presumably migrated to other plants. This was the only mobile instar and dispersal by this mechanism has been suggested by Quintana (1956). The first instar scales were inconspicuous on the plants and there may be a diapause or inactive stage over winter, as no second instar larvae were found between April and August. The second instar was immobile and was found exposed on leaves and also floral bracts when *C. edulis* was in flower. The second instar developed either into a male imago or into a third instar female which will eventually contain eggs. The females were immobile and progressively formed a white, waxy coat over their eggs. Upon death, the female body formed an additional part of the protective coat. The final generation females appeared in late March and in April. The eggs hatched soon after the death of the female. Males are the only winged form of this species (Pesson 1941) and the occurrence of males in colonies of scales varied from none to a high proportion in different locations at the study site.

The presence of scale insects seemed to affect the growth of the plants. Of 10 plants with scales, none had new growth in late March whereas 8 out of 10 plants without scales exhibited new growth (Fisher exact probability test,  $p < 0.001$ ). There was no obvious scar left on the leaves where the scales had been feeding.

Two native species of ant tended the scale, *Crematogaster* sp. J.D.M. 33\* and *Iridomyrmex* sp. J.D.M. 9\*. The ants were present throughout both the day and night, soliciting honeydew by caressing the back of the scale with their antennae. The two ant species occurred in mutually exclusive areas.

Not all populations of scale were tended by ants. One population which was not tended during our observations was known to have been tended by an ant species, *Iridomyrmex conifer* Forel, two years previously. This population of ants moved from the study area due to a scarcity of food (nectar) brought about by three successive years of drought (P. McMillan, pers. comm.). The scales remaining in this area were not tended by ants but bees were frequently observed removing honeydew from the scales. In the absence of ants and bees, the scales were observed to remove honeydew

\* Voucher specimens of the ants are housed in Dr J. D. Majer's collection at the Western Australian Institute of Technology.

by the active expulsion of droplets. These droplets landed about five millimetres away from the body of the scales which expelled the droplets.

The coccinellid, *C. montrouzieri*, was the predator of the scale at the study site. This predator was always present with the populations of the scale although the species is known to eat other Homoptera at the study site. When the adult predator approaches the scale insect it first solicits the release of honeydew in a manner similar to that of the ants that tend this species. The predator eats the scale after consuming the honeydew. Any remaining part of the dead scale drops off the plant. The larva of the coccinellid is also predatory and eats its way into the remains of the female body which contains the eggs and proceeds to eat the eggs from the inside.

Two species of parasite could be distinguished within the scales at the study site. These have not been identified although the scale is known to have a number of parasites in South Africa and Argentina (Peringuey 1892; Quintana 1956).

### Methods

The plants used in the experiments were infested only with female scales. We removed ants, predators or both ants and predators from 5 branches for each experiment and used 5 nearby branches as controls. The branches in the four treatments did not differ statistically in leaf number and in wet weight at the end of the experiment (Table 1). The branches were not inter-twined with other plant material and were spread along the ground.

TABLE 1

Mean  $\pm$  standard error with range in parenthesis of the number of leaves and the wet weight of branches (with leaves). Sample size is 5 in each case. Analysis of variance on number of leaves and wet weight of branches showed no differences.

Treatment	Number of leaves	Weight of branches (gm)
Control	46.0 $\pm$ 5.79 (32-62)	116.9 $\pm$ 18.0 (62.2-172.6)
Ants excluded	69.6 $\pm$ 17.13 (38-124)	203.0 $\pm$ 52.04 (66.8-360.7)
Predators excluded	49.2 $\pm$ 12.53 (18-94)	170.5 $\pm$ 43.21 (70.7-328.5)
Ants and predators excluded	34.6 $\pm$ 5.13 (22-53)	103.1 $\pm$ 27.56 (60.2-211.0)

Ants were excluded from branches by placing cloth sheets between the branch and the ground. The cloth edges and stem of the plant at the edge of the cloth were covered with grease. The edge of the cloth was secured to the ground. All leaves and other material which could form a bridge for the ants to the experimental area were removed and ants within the experimental area were removed by hand.

Predators were excluded from the plants by placing netting of 2 mm mesh over the plants. The circumference of the netting was pegged into the ground and the netting raised, tent-like, above the experimental area. All predators were removed by hand from within this area however, ants were observed to pass through the mesh to tend the scales.

The above methods were combined to exclude both ants and predators. The 5 control branches were left unaltered.

Each branch was examined 6 times over a period of 18 days in April and during these visits we counted scales and checked that the experimental exclusions were successful. At the start of the experiment we counted second instar scales. The branches did not have overlapping generations and the experiment ceased when first instar larvae emerged from the egg cases. Thus the final number of scales were those that will contribute young to the next generation.

### Results

There were wide differences in the mortality of scales among the treatments, with more scales dying when both ants and predators were removed (Table 2). However the number of scale in the control treatment also decreased over the time we observed the scales. We suspected that uncontrolled factors such as parasites could be responsible. To account for these changes over time we used analysis of covariance to compare the treatments (Li 1964). Regressions were calculated with the percentage of the original number of scales surviving as the dependent variable (Y's) (arcsine transformed, in radians) and time (in days since the start of the experiment) as the independent variable (X's). Analysis of covariance was then used to compare the slopes of the regressions and the adjusted mean percentage of surviving scale (based on the overall mean sample day). The

TABLE 2

Mean  $\pm$  standard error with range in parenthesis of the original number of scales, the final number of scales, and the percentage survivorship. Sample size is 5 in each case.

Treatment	Original number of scales	Final number of scales	Percentage surviving
Control	54.8 $\pm$ 5.95 (36-68)	20.2 $\pm$ 6.58 (9-46)	37.0 $\pm$ 9.78 (22.1-74.2)
Ants excluded	58.2 $\pm$ 6.51 (38-69)	7.0 $\pm$ 0.84 (5-9)	13.0 $\pm$ 2.82 (8.0-23.7)
Predators excluded	55.2 $\pm$ 6.28 (32-70)	21.2 $\pm$ 2.76 (15-31)	40.7 $\pm$ 6.95 (25.0-59.4)
Ants and predators excluded	104.4 $\pm$ 15.5 (54-151)	10.8 $\pm$ 2.91 (3-19)	9.8 $\pm$ 1.94 (5.5-15.3)

TABLE 3

Analysis of covariance of the percentage of scales surviving among experimental treatments. The percentages (arcsine transformed) of the surviving scales (Y) were regressed against time, in days (X). Y's are adjusted to X = 9.2 days. Results of analysis of covariance:  $F = 443.13$ ,  $p < 0.001$  that the overall regression  $\beta = 0.0$ ;  $F = 3.22$ ,  $p < 0.05$  that  $\beta_1 = \beta_2 = \dots$ ;  $F = 13.95$ ,  $p < 0.001$  that  $Y_1 = Y_2 = \dots$  Sample size is 30 for each regression.

Treatment	Regression equation	$r^2$	Probability $\beta = 0.0$	Adjusted Y	Adjusted % of surviving scales
Control	$Y = 1.50 - 0.05X$	0.73	<0.001	1.02	85.2
Ants excluded	$Y = 1.44 - 0.07X$	0.88	<0.001	0.85	75.1
Predators excluded	$Y = 1.56 - 0.05X$	0.77	<0.001	1.13	90.4
Ants and predators excluded	$Y = 1.53 - 0.07X$	0.79	<0.001	0.92	80.0

results of this analysis are given in Table 3. There were differences among the slopes of the treatments due to a greater mortality rate for the two treatments where ants were removed. Similarly the adjusted percentages of surviving scales were lower where ants were removed. Obviously the scale benefited from the presence of the ants but from a comparison of individual regressions there was no difference between the control and the sample where the predator only was removed. The scales had sooty mould infestations in treatments where the ants had been removed. The mould appeared to be growing on honeydew and was probably the cause of the differences in mortality rates.

### Discussion

Ants have often been observed to remove honeydew from scales thus preventing the growth of sooty mould (Way 1963). Our experiment indicates that the removal of honeydew may be more important for survival than the actions of predators. However the ability of some scale to survive without ants would seem to be an important attribute of a species capable of colonizing new areas. That the scale can expel honeydew away from their bodies indicates that tending by ants may not be necessary but this probably depends on the density of scale. When scales are closely packed an expelled drop of honeydew could land on another scale. Further experiments on the relationship between these scale and ants would need to take density into account.

*C. montrouzieri*, is a well known predator of homoptera and has been used widely as a biological control agent (Barlett 1973; Hodek 1973). Often this insect needs to be mass-reared for release to ensure a sufficiently large number to effect control of insects, chiefly mealybugs (*Pseudococcus* spp.). In our example this predator may have been too low in numbers to affect the scale or the scale may not have been the preferred prey. The predator may also be more important at another time of the year but more experimentation would be needed to show this.

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### BOOK REVIEW

**Guide to the aquatic insects of New Zealand** by Michael J. Winterbourn and Katharine L. D. Gregson. 1981. *Bull. ent. Soc. N.Z.* 5. 80 pages, 222 text-figs (100 of whole animals). Price NZ\$9.00 (overseas orders add \$1.00 for surface postage); educational institutions ordering 5 or more copies, \$7.00 each.

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## COVER

Illustrated by Deborah Kent

Shows the face of the larva, *Tapeigaster annulipes* Macquart (Diptera: Heleomyzidae). The genus *Tapeigaster* is endemic to Australia, where it is widely distributed through temperate regions. The larvae of *Tapeigaster* are known to live in various kinds of fungi.

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## A NOTE ON BUPRESTIDAE (COLEOPTERA) OBSERVED AT LIGHTS

By Geoff Williams

C/- Post Office, Lansdowne, N.S.W. 2435

In North America buprestids of the genus *Melanophila* Eschscholtz are commonly encountered at forest fires (Evans 1966) and in Australia the "fire beetle", *Merimna atrata* Hope, frequently occurs at both lights and fires (Poulton 1916). In Australia, however, buprestids are generally considered to be blossom and foliage frequenters.

During nights in the late spring and early summer of 1980 representatives of four buprestid genera were taken at a range of artificially emitted light sources on our property at Lansdowne. On each occasion the light was located in a cleared space adjoining a wet forest complex.

On 27 November five specimens of *Pseudoanilara cupripes* (Macl.), one specimen of *Torresita cuprifera* Kirby and two specimens of *Melobasis ?purpureascens* F. were taken at a high intensity mercury vapour light. On 8 December a fasciated *Melobasis* sp. came to a "black" light and previously on 2 December a *Chrysobothris* sp. was captured at a low intensity caravan courtesy light during light rain. Thus five species were encountered from a wide range of light intensities.

Species of two further genera, *Anilara* Thoms. and *Alcinous* Deyr., commonly observed during the day in the area where these lights were set were not observed at light.

It is possible that the attraction stimulus in each instance was heat convection rather than light emission as Evans (1966) has demonstrated that *Melanophila acuminata* De Geer will exploit subtle differences in temperature under experimental conditions. Response times to light emission, however, are much less (Evans 1966). I am unaware of any previous records, excepting *Merimna*, of Australian buprestids being attracted to lights.

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## A RECORD OF *ONTHOPHAGUS PARVUS* BLANCHARD (COLEOPTERA: SCARABAEIDAE) FROM THE EUROPEAN RABBIT

By P. G. Allsopp

Department of Primary Industries, P.O. Box 102, Toowoomba, Queensland, 4350.

### Abstract

The prehensile dung beetle *Onthophagus parvus* Blanchard is recorded from the European rabbit in southern Queensland. This is the first record of a non-macropod host.

Two groups of Australian dung beetles of the genus *Onthophagus* Latreille have developed mechanisms which allow the beetle to cling to the fur of mammals. In the *glabratus* species-group this is achieved by modification of the tarsal claws, a prolongation of the edge of the last tarsal segment between the bases of the claws, and an absence or a great reduction of the pulvilli (Matthews 1972). There are five prehensile species in the *glabratus* group and, apart from a record of beetles clinging to the fur of goats, all reliable records of hosts are macropods (Matthews 1972).

*O. parvus* Blanchard (one of the *glabratus* group) occurs from the interior of New South Wales across the northern part of the continent as far as Port Hedland, Western Australia, in areas of about 400-1300 mm of annual rainfall. Matthews (1972) records it from the fur of the agile wallaby [*Macropus agilis* (Gould)], northern nail-tail wallaby [*Onychogalea unguifera* (Gould)] and spectacled hare-wallaby (*Lagorchestes conspicillatus* Gould).

On the night of 9th December 1980 six specimens of *Onthophagus* were found clinging to the fur on the ventral posterior of an adult female European rabbit, *Oryctolagus cuniculus* (L.), captured near Condamine, Queensland (150°07' E, 26°58' S). Only one specimen was captured and proved to be *O. parvus*. This was the second time such beetles had been sighted on rabbits during the previous two years (M. McManus, pers. comm.).

This appears to be the first record of a prehensile *Onthophagus* from rabbits. No scarabaeids were recorded from rabbits by either Myktytowycz (1957), Shepherd and Edmonds (1973, 1976) or Williams (1972).

### Acknowledgement

I am indebted to Mick McManus, Chief Rabbit Control Officer, Roma, for bringing the specimen to my attention.

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Williams, R. T., 1972. The distribution and abundance of the ectoparasites of the wild rabbit, *Oryctolagus cuniculus* (L.) in New South Wales, Australia. *Parasitology* 64: 321-330.

## FURTHER STUDIES ON THE SYSTEMATICS OF AUSTRALIAN DIPLURINAE (ARANEAE: MYGALOMORPHAE, DIPLURIDAE): THE TAXONOMIC STATUS OF *PROSHERMACHA* SIMON AND *CHENISTONIA TEPPERI* HOGG

By Barbara York Main

Zoology Department, University of Western Australia, Nedlands, W.A. 6009.

### Abstract

*Prospermacha* Simon, formerly placed in the Ctenizidae is transferred to the Diplurinae (Dipluridae). The two species *P. tigrina* Simon and *P. subarmata* Simon are regarded as conspecific. *Prospermacha* is synonymised with *Chenistonia* Hogg. *P. tigrina* and *subarmata* are tentatively synonymised with *Chenistonia tepperi* Hogg. The systematic confusion of the *Chenistonia tepperi* "superspecies" in south-west Western Australia is discussed.

### Introduction

A study of the systematics and biology of Australian mygalomorphs was begun by the author in 1952. As this work developed, the biological prominence of the Diplurinae compared to other groups of mygalomorphs, in several geographic regions of the continent became apparent. However, at the same time the taxonomy of the group proved exceptionally difficult and attributing names to biologically distinct populations was frequently impossible. This was due to two reasons. Firstly some of the early descriptions of species were inadequate, some genera and species were unnamed, certain types were lost or temporarily "missing" and access to types which could be located was difficult. At that time loans were not permitted from several major institutions both in Australia and overseas, where many Australian types were deposited. Perforce, visits to the relevant institutions had to be made in order to examine such types. Secondly, the Diplurinae in Australia are complex due to a long evolution in isolation which has resulted in numerous convergences. Many species, and even genera, although distinguishable on biological criteria, exhibit confusing morphological parallels, especially of female specimens. Thus my study of systematics of the Diplurinae has been long and tedious and many of the taxonomic problems are only now beginning to be solved.

My taxonomic study of the Mygalomorphae was initially planned as a monograph and much information has been accumulated and manuscript descriptions of many species set aside until such time as generic revisions would appear to be reasonably complete. However a monographic presentation is impractical and some results have already appeared in smaller papers. This paper is the sixth in a series dealing solely with systematics of the Diplurinae. Earlier publications in which I described or reviewed genera or species of Diplurinae are: Main (1954, 1969, 1972, 1975, 1977 and in press, a) and Main and Mascord (1969).

The purpose of this paper is to discuss the taxonomic status of *Prospermacha* Simon and the *Chenistonia tepperi* superspecies.

The following abbreviations of depositories are used: BMNH, British Museum of Natural History; ZMB, Zoologisches Museum Berlin; ZMH, Zoologisches Museum Hamburg.

#### **Status of *Proshermacha***

Simon (1908) erected the genus *Proshermacha* to contain two species, *tigrina* and *subarmata*, from southwest Western Australia. The description of *P. tigrina* is more complete and precedes that of *subarmata*. Although he did not designate *tigrina* as the type of the genus, Simon clearly regarded it as the type species in that he described *subarmata* only in respect of how it differed from *tigrina*. Rainbow (1912) incorrectly designated *subarmata* as the type species with which designation Petrunkevitch (1928) and Bonnet (1958) concurred. In accordance with Article 69 (a) (iii) and (vi) of the International Code of Zoological Nomenclature, Rainbow's designation, although arguably incorrect must be accepted.

Simon placed the genus in the group (or tribe) Nemesieae in the Ctenizidae, mainly on the basis of the bipectinate superior tarsal claws but also because he regarded the bristles on the chelicerae as a rastellum. Examination of one of the syntypes of *P. tigrina* and three syntypes of *subarmata* has revealed that the specimens although having bipectinate superior claws, do not possess a rastellum. Carapace, abdomen, spinnerets, sternum, labium and maxillae of one syntype (from Harvey) are illustrated (Figs 1-3).

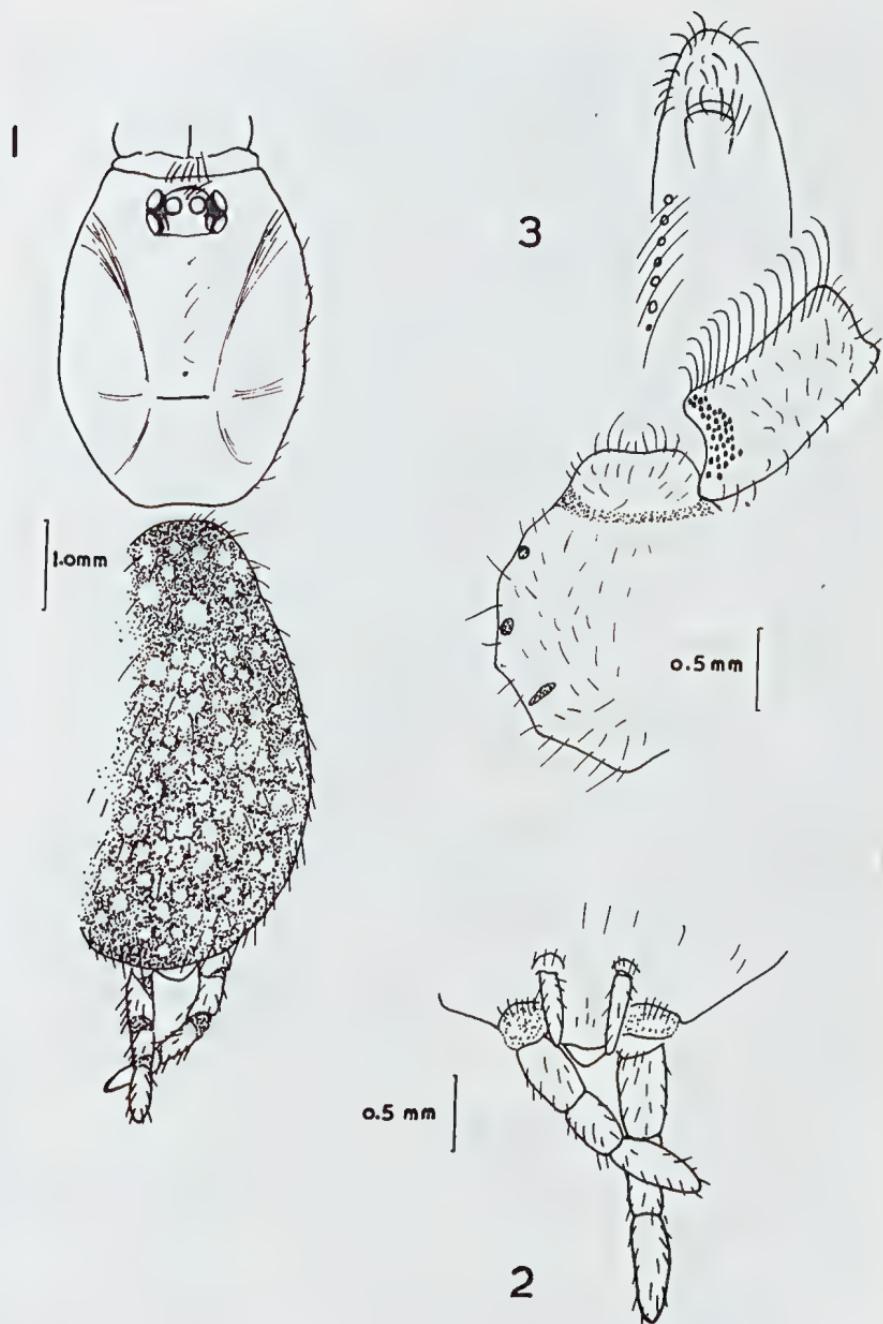
Carapace lengths of syntypes are as follows: *P. tigrina*, 3.25 mm; *P. subarmata*, Harvey, 3.6 mm, Wooroloo, both specimens 3.0 mm. Cheliceral teeth: *P. tigrina*, 7 promarginal and a few basal; *P. subarmata*, Harvey, 7 promarginal and 13 (and 12) basal right and (left) respectively.

The bipectinate superior tarsal claws and the relatively long posterior lateral spinnerets, with tapering terminal segment, indicate that the specimens are not ctenizids but diplurines. In addition, the following combination of features suggests that the species belong in *Chenistonia* Hogg: a straight or slightly recurved fovea; pronounced eye tubercle; teeth on only inner margin of cheliceral furrow plus a basal group of granule like teeth; marginal sternal sigilla; mottled pattern on dorsum of abdomen; scopula on at least anterior tarsi and metatarsi; a pair of proximal ventral spines on palp tarsus. All are juvenile specimens and thus specific identity is difficult. Nevertheless they appear to be conspecific and from the characters noted, combined with the localities from which the specimens were collected it is deduced that they probably belong to the species currently identified as *Chenistonia tepperi* Hogg. Although Hogg had five syntypes from four localities, only two ("otypes") from Ardrossan (in the British Museum of Natural History) can be traced. Thus Ardrossan, which happens also to be the first listed locality, is designated as the type locality.

#### **Genus *Chenistonia* Hogg**

*Chenistonia* Hogg, 1901. Type species by original designation: *Chenistonia maculata* Hogg 1901.

*Proshermacha* Simon, 1908. Type species by subsequent designation (Rainbow 1912): *Proshermacha subarmata* Simon 1908. New Synonymy.



Figs 1-3. Syotype (Harvey) of *Proshermacha subarmata* Simon: (1) carapace and abdomen, dorsal view, (2) spinnerets, ventral view, (3) sternum, labium, maxillae and chelicerae. (Note extrusion of spinnerets exposing membranous areas in dorsal view).

*Chenistonia tepperi* Hogg

*Chenistonia tepperi* Hogg, 1902, p. 137. Five female syntypes from Ardrossan, Kangaroo Island, Burnside and Blakiston, South Australia. Two female "cotypes" from Ardrossan (BMNH, examined), other syntypes lost.

? *Proshermacha subarmata* Simon, 1908, p. 364. Three syntypes, all juveniles, 1 from Harvey, Western Australia (ZMH, examined), 2 from Woorooloo, Western Australia (ZMB, examined). New Synonymy.

? *Proshermacha tigrina* Simon 1908, p. 363. Female syntype from Serpentine, Western Australia (probably originally in ZMH, lost). Juvenile syntype from Jarrahdale, Western Australia (ZMB, examined). New Synonymy.

**Identity of the *Chenistonia tepperi* superspecies**

*Chenistonia tepperi* as at present delimited is distributed in southern Australia from the west coast to Adelaide (Main 1972, 1976 and in press, b) and includes several offshore islands e.g. Rottnest and Kangaroo Islands. In the western part of its range it comprises at least two behavioural forms which may represent distinct species (unpublished field data, documentation in preparation as part of the revision of the genus *Chenistonia*). It is not possible from the juvenile specimens of *Proshermacha* to state which behavioural form of *Chenistonia* they represent. The common and widespread form (designated race "A") builds a deep, sinuous burrow and appears to be continuous across the range of the "superspecies" and is at present regarded as *Chenistonia tepperi*. The other form (designated race "B"), which can be differentiated in life on colour (it is black instead of fuscous), builds a shallow burrow, frequently under logs. Male characters of both forms are similar. This complex of "races" comprising the "superspecies", i.e. a South Australian form which is more or less continuous with race "A" of the two Western Australian races (which are sympatric in the northern jarrah forest) cannot at present be resolved. Further field observations are required, and correlations made, of data so acquired, with subtle morphological distinctions. However, in the meantime there is a great deal of pressure for identifications of this species complex from practically-orientated bodies, such as forestry and mining concerns and biologists conducting fauna surveys in relation to rehabilitation of landscapes and establishment and management of parks. Consequently, an immediate appraisal of the taxonomy of this group, although inconclusive, is required.

A nomenclatural problem associated with synonymising *Proshermacha* with the *Chenistonia tepperi* "superspecies" arises from the uncertainty of the status of the various populations of this "superspecies", e.g.: (a) There is one South Australian species (*Chenistonia tepperi* Hogg) and (b) There are two Western Australian biological populations (race "A" and race "B") of which one or both may be conspecific with *Chenistonia tepperi* (at present they are both identified as part of the *Chenistonia tepperi* "superspecies").

The alternative nomenclatural solutions are dependent on the status of these populations which is still uncertain, e.g., there are three possibilities: (i) Both the Western Australian populations, race "A" and race "B", are

conspecific with *Chenistonia tepperi* Hogg. (ii) Only one of the Western Australian populations, race "A", is conspecific with *C. tepperi* and the other one, race "B", is a distinct species. Thus two species in W.A.: one continuous across the southern part of Western Australia and South Australia (= *Chenistonia tepperi*) and one (= unnamed species) restricted to the northern jarrah forest of southwest Western Australia. (iii) Neither Western Australian population is conspecific with *C. tepperi*. Thus three species: one restricted to South Australia (= *C. tepperi*) and two in Western Australia [race "A" = *Chenistonia intricata* (Rainbow and Pulleine) which until now I have regarded as a synonym of *C. tepperi* (unpublished) and race "B", an unnamed species].

From field observations and my collections the second "solution" is favoured as there does appear to be a continuous population of one of the biological "forms", i.e. race "A" (documentation in preparation). If the third "solution" is correct several names are available. If also my present opinion that the three following species are conspecific remains unaltered and is correct, then each name is available in the following order of precedence:

*Aname maculata* Rainbow and Pulleine 1918, p. 151

*Aname intricata* Rainbow and Pulleine 1918, p. 157

*Chenistonia auropilosa* Rainbow and Pulleine 1918, p. 160

Taking the first available name, this would raise problems of priority and homonymy since the type species of *Chenistonia* is *C. maculata* Hogg from Macedon, Victoria (Hogg 1901). Therefore the next available name is *intricata*.

Returning to *Proshermacha* the significant point is that whatever the specific status of the two *Proshermacha* species the genus *Proshermacha* becomes a synonym of *Chenistonia*. If *C. tepperi* stands for both the Western Australian populations [solution (i) above] then there is no problem of nomenclature and the species names *tigrina* and *subarmata* become synonyms of *C. tepperi*. However if there are two Western Australian species [solution (ii) above] it would not be possible to know with certainty with which species *P. subarmata* is conspecific (i.e. *C. tepperi* or the "unnamed") because of the juvenile state of the *Proshermacha* specimens *but conspecificity with tepperi is most probable*. Finally, if solution (iii) above regarding the status of the *Chenistonia* species is correct then the name *subarmata* has priority over the three names discussed above, i.e. *A. maculata*, *A. intricata* and *C. auropilosa*. However there would still remain the problem whether *P. subarmata* is conspecific with race "A" (= *C. intricata*) or race "B" (unnamed *Chenistonia* sp.).

Consequently, it becomes impossible to attribute with certainty the specific name *subarmata* to a population. Furthermore, the names *Proshermacha tigrina* and *subarmata* have not been cited, except in catalogues, since erection of the genus in 1908. While recognising *Proshermacha* as a synonym of *Chenistonia* the most practical approach is to disregard the specific names

*subarmata* and *tigrina*, although strictly speaking they cannot be considered as *nomina obliterata* under the present terms of the International Code of Zoological Nomenclature.

### Acknowledgements

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## AN ANNOTATED LIST OF THE CARABIDAE (COLEOPTERA) RECORDED FROM CAVES IN NEW GUINEA

By R. M. Emberson and B. P. Moore

Lincoln College, Canterbury, New Zealand  
and

C.S.I.R.O., Division of Entomology, Canberra, A.C.T., Australia

### Abstract

Twelve genera and eighteen species of Carabidae are listed from caves in the islands of New Guinea. All three major levels of adaptation to cavernicolous life are represented and the Agonini form the dominant element in the subterranean fauna.

### Introduction

The extensive cave systems of New Guinea are now receiving increased attention from speleologists and several expeditions have been mounted in recent years, with the object of investigating the fauna. Notable among these are the British Speleological Expedition to Papua New Guinea, 1975 (Chapman 1976) and the Australasian Atea Expedition, 1978 (Smith 1980), in which one of us (RME) took part. Both of these major expeditions produced extensive collections of cave animals. The augmented level of exploration seems likely to be maintained for some years at least and it therefore appears desirable to draw together all available records in chosen groups, thereby providing basic lists to which the results of future expeditions may readily be attached.

Such is the aim of the present paper, which covers the family Carabidae, a dominant group in cave beetle faunas generally and evidently so in New Guinea. All published records known to the authors are included, together with hitherto unpublished results from the British expeditions of 1975 (BSE75) and 1978 (BSE78) (specimens determined by BPM), the Australasian expedition of 1978 (ATEA78) (specimens determined by RME), and data from material from earlier limited excursions, that have come to their notice. For the purposes of the list, the New Guinea region is taken to include the whole of the main island of New Guinea, plus the dependencies of Papua New Guinea.

### List of species

#### Subfamily PAUSSINAE

##### Tribe Ozaenini

*Pseudozaena (Trichozaena) cavicola* Moore. NEW IRELAND: Kabase Cave (P. Beron, BSE75) (Moore 1978).

#### Subfamily SCARITINAE

##### Tribe Clivinini

*Clivina* sp. PAPUA: Atea Kananda, Yikebo (ATEA78).

#### Subfamily PTEROSTICHINAE

##### Tribe Agonini

*Altagonum cracens* Darlington. NEW GUINEA: Great Cave (Bem Tem), Telefomin (T. Hayllar) (Darlington 1971).

*Altagonum misim* Darlington. NEW GUINEA: Great Cave (Bem Tem), Telefomin (B. Craig and T. Hayllar) (Darlington 1971); Bem Tem, Telefomin (P. Beron and P. Chapman, BSE75); Hulup Tem, Telefomin (P. Beron, BSE75); Bolam Tigiin, Telefomin (P. Beron, BSE75); Nong River Cave, W. Sepic Province (P. Chapman, BSE75); Ogon II Cave, near Gogome, Chimbu Province (P. Beron, BSE75); Mebikombogo Cave, near Gurema, Chimbu Province (P. Beron, BSE75). PAPUA: Ila Kananda, Nali Gorge (ATEA78); Iawarere Caves, near Port Moresby (R. A. Carver and T. L. Fenner); Bilel Tem, Hindenberg Wall (R. Plumley, BSE78); Um Tem, Bikatokbip (R. Plumley, BSE78).

*Altagonum sphodrum* Darlington. PAPUA: Yarom Deng Tem, Finim Tel (P. Beron, BSE75); Ok Kumun Tem, Finim Tel (P. Beron, BSE75); Finim Tem, Main Cave, Finim Tel (P. Beron, BSE75); Agim Tem, Finim Tel (BSE75); Atea Kananda, Duna Sands and Ooze Cruise (ATEA78).

*Altagonum* sp. n. PAPUA: Atea Kananda, Pikers Sump (ATEA78).

*Colpodes sinuicauda* Darlington. NEW GUINEA: caves near Telefomin (B. Craig) (Darlington 1971).

*Montagonum* sp. near *pandum* Darlington. PAPUA: Atea Kananda, Duna Sands (ATEA78).

*Gastragonum caecum* Moore. NEW GUINEA: Selminum Tem (P. Chapman, BSE75) (Moore 1978).

*Nebriagonum foedum* Darlington. WEST IRIAN: Maimbobo Cave, North Duman, Porol Range (F. Parker) (Darlington 1971).

*Notagonum altum* Darlington. PAPUA: Hyom Tem, near "Girtoil" (P. Chapman, BSE75).

*Notagonum dentellum* Darlington. PAPUA: Ila Kananda, Nali Gorge (ATEA78).

*Notagonum margaritum* Darlington. NEW GUINEA: Ogon II Cave, near Gogome, Chimbu Province (P. Beron, BSE75); Bem Tem, Telefomin (P. Beron and P. Chapman, BSE75).

*Notagonum* sp. near *margaritum* Darlington. PAPUA: Atea Kananda, Duna Sands (ATEA78).

*Potamagonum diaphanum* Darlington. PAPUA: Atea Kananda, Duna Sands (ATEA78).

*Speagonum mirabile* Moore. NEW GUINEA: Okemimal Tem and Selminum Tem, near Tifalmin (P. Beron and P. Chapman, BSE75) (Moore 1978).

*Genus nov. sp. 1.* PAPUA: Atea Kananda, Binatang Passage (ATEA78).

*Genus nov. sp. 2.* PAPUA: Atea Kananda, Binatang Passage (ATEA78).

### Discussion

Although the above list is evidently no more than an interim summary of the known carabid fauna, the data available are already sufficient for some generalisations to be made. In particular, the dominance of the tribe Agonini\* is very obvious. This is atypical for cave faunas in general but is entirely to be expected in New Guinea, where the tribe is exceptionally well represented and is dominant in mesophile habitats (Darlington 1971).

\* = Platynini = Anchomenini: the correct name has yet to be settled

Information concerning the habits and biology of the various species recorded here is scant but from the wide range of morphological adaptation displayed, it seems clear that all three currently recognised levels of cavernicolous status, namely troglobite, troglophil and trogloxene, are represented. However, it is not always possible to specify with confidence the status of any given species.

From its extremely attenuate form, vestigial eyes, flightlessness and occurrence deep within the Selminum Tem system, *Speagonum mirabile* is evidently a troglobite and it displays the highest level of adaptation yet discovered in the region. As far as can be judged from the inadequate material currently available, *Genus nov. sp. 1* and *sp. 2* also appear to be well adapted troglobites. *Gastragonum caecum* and *Altagonum* sp. n. are evidently troglobitic representatives of largely surface dwelling genera.

*Pseudozaena cavigola*, which was found in large numbers on bat guano, is presumably a predator of other, guano-feeding, arthropods; it is fully winged and closely related to a Malaysian species that is known to fly to light. Thus it is probably a troglophil. *Nebrriagonum foedum*, discovered on fruit-bat droppings, belongs to an entirely flightless genus of montane mesophiles but may also be a troglophil. *Montagonum* sp. near *pandum* is essentially similar.

The remaining species of the list are all fully winged and show little or no obvious adaptation to life in caves; most have already been taken in surface habitats. However, from the numerous records from caves, *Altagonum misim* seems clearly more than a casual visitor to the habitat and may be classed as a troglophil. Its more localised congener, *A. sphodrum* shows a tendency in some populations (notably those in the Atea Kananda) to attenuation in body form and reduction in eye size and also seems to qualify for troglophil status. The large and worldwide genus *Clivina* is dominant in the fossorial faunas of wet places, such as lake and creek margins, and the single record from a cave may well be an incidental occurrence. For the other listed species, the data do not distinguish between regular and casual occurrences.

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## OGYRIS GENOVEVA GELA WATERHOUSE (LEPIDOPTERA: LYCAENIDAE) FEEDING AT SAPFLOW, AND THE FIRST RECORD OF THIS SUBSPECIES FROM VICTORIA

By Peter S. Valentine

Geography Dept., James Cook University, Townsville, Qld 4811

Common and Waterhouse (1981: 53) record two Australian butterfly species attracted to feeding lures, *Polyura pyrrhus sempronius* (F.) and *Vanessa itea* (F.), while Brunet (1977) also observed *Heteronympha merope merope* (F.) feeding on tree sap. Monteith and Kerr (1977) report the attraction of *Lexias aeropa* (L.) to rotting banana skins and comment that *Apaturina erminea* (Cramer) is attracted to over-ripe bananas. More recently Hawkeswood (1980) has reported *Geitoneura klugii* (Guér.-Mén.) feeding on sap. I have observed both *Melanitis leda bankia* (F.) and *Mycalesis terminus terminus* (F.) feeding on rotting mangoes in the Townsville area.

Of particular interest, however, is a record of *Ogyris genoveva gela* Waterhouse being attracted to sapflow. On 5 January 1980, near Willis, near the Victorian/New South Wales border along the Snowy River, a number of specimens were found feeding at sapflows on two adjacent trees. Both sexes were present, congregating at a few places up the trunk and along branches of the two trees. Each place was also visited by numerous large Diptera and some ants, all apparently attracted by the same exudate. The trees were apple box, *Eucalyptus bridgesiana*, a fairly common species in eastern Victoria and New South Wales. Despite a careful search no other trees in the vicinity were found to attract the butterflies during the three days observations were made. Some of the sapflow locations on the trees were not obvious but could be identified by a small cluster of Diptera and the inevitable return of an *Ogyris* within a short time. The feeding butterflies were quite persistent, usually returning to the feeding place within a few minutes after disturbance.

The presence of *Ogyris genoveva gela* in Victoria is also of interest as this subspecies is otherwise restricted to New South Wales and the A.C.T. Although no larvae or pupae were found a female was observed ovipositing on some of the very numerous clumps of mistletoe which festoon a high proportion of the eucalypts in this area. Similar habitat extends well into Victoria.

### Acknowledgement

Advice on the preparation of this paper from M.S. Moulds is gratefully acknowledged.

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## A NOTE ON THE STATUS OF *ORNITHOPTERA MERIDIONALIS TARUNGGARENSIS* (JOICEY AND TALBOT) (LEPIDOPTERA: PAPILIONIDAE)

By D. L. Hancock

National Museum, P.O. Box 240, Bulawayo, Zimbabwe

### Abstract

The taxon *tarunggarensis*, currently placed as a subspecies of *Ornithoptera meridionalis* (Rothschild), is transferred to *O. paradisea* Staudinger, as *O. p. tarunggarensis* (Joicey and Talbot) comb. nov. A population of true *O. meridionalis* occurs nearby.

### Introduction

In January-February, 1921, C., F., and J. Pratt collected four female *Troides* (*Ornithoptera*) specimens near the Wanggar River in Irian Jaya. Three of the females were taken at Nomnangihé, 40 km south of Wanggar, the other 25 km from the coast. Joicey and Talbot (1927) described two of these females, one from each locality, as *Troides meridionalis tarunggarensis* (Fig. 1). The other two specimens have been referred to *paradisea arfakensis* Joicey and Noakes (Haugum and Low, 1979).

The anomaly of these two closely allied species occurring together, in view of their allopatric occurrence elsewhere, has remained largely unnoticed, let alone questioned, since their original discovery. Haugum and Low (1979) gave a detailed discussion of the known specimens from this area, including a male from the foothills of the Weyland Mountains, yet maintained them as two specifically distinct populations. D'Abrera (1975) also maintained *tarunggarensis* as a subspecies of *meridionalis*.

### Discussion

In assessing this anomalous population several points need to be considered:—

- 1.—Females of both alleged species (*meridionalis* and *paradisea*) occur together at Nomnangihé, altitude 650 m (2000').
- 2.—A female of alleged *meridionalis* was taken nearer the coast, at an altitude of 200 m (600').
- 3.—A male, referable to *paradisea* but morphologically distinct, was taken in the foothills of the Weyland Mountains, altitude 100-200 m (Haugum and Low, 1979).
- 4.—A further male (Fig. 2), identical to that above, has been taken near the coast (Wanggar R., west of Nabire), at an altitude of about 100 m (Straatman, pers. comm.).

The above records show that both *paradisea* and alleged *meridionalis* occur together at both low and high altitudes within the Wanggar-Weyland Mountains area. and while both males and females of *paradisea* occur, only females of *meridionalis* have been reliably reported.

A comparison between descriptions and illustrations of *tarunggarensis* and the Wanggar *paradisea* females (D'Abrera, 1975; Haugum and Low, 1979) indicates that the only difference of any significance is the degree of projection of the hind wing tornal angle, being rounded in *tarunggarensis* (and other *meridionalis*) and distinctly pointed in *paradisea*.

Haugum and Low (1979) use this as a specific character to separate the otherwise virtually indistinguishable females of these two species. However, this is an unreliable character, at least in some populations. Of two female *paradisea borchi* Haugum and Low in the collection of the National Museum, Bulawayo, one has a distinctly pointed hind wing tornus, the other has a rounded tornus (Fig. 3), similar to that of *meridionalis*. Both specimens were collected at Ravik, in the West Sepik district; both have yellow-streaked femora and lack pale markings in the hind wing cell. A pointed or rounded tornal angle is also evident in other birdwing populations, e.g. *priamus admiraltatis* Rothschild (Haugum and Low, 1979: fig. 131) and this character therefore cannot be used to differentiate between species.



Figs 1-3. *Ornithoptera paradisea*: (1) *O. p. tarunggarensis*, female; (2) *O. p. tarunggarensis*, male; (3) *O. p. borchi*, female.

Other characters, such as pattern details, presence of white basal dusting on the fore wing and abdominal colour, are also variable, examples of *paradisea* females from other Irian Jaya populations sometimes approaching the *meridionalis* phenotype.

Populations of true *meridionalis* have recently been discovered in the Kamrau Bay and Lake Jamur areas of Irian Jaya, approximately 200 km west of the Weylands Mts (Pasternak, 1981; Kobayashi, 1981). Females from Kamrau Bay are very similar to typical *meridionalis* and "typical" *tarunggarensis*. However, *tarunggarensis* (and *paradisea*) females differ from those of *meridionalis* from both populations in having a grey dusting over much of the fore wing discal pale areas, contrasting with the purer white discal areas of

*meridionalis*. The hind wing submarginal pale area is also less sharply separated from the marginal black band in *tarunggarensis* and *paradisea* than in *meridionalis*. The only other character appears to be a structural one. In both *meridionalis* populations (and most *paradisea* populations) the hind wing has vein 3 closer to vein 2 than to vein 4; in *tarunggarensis* and *paradisea arfakensis* vein 3 is closer to vein 4 than to vein 2.

The two *tarunggarensis* type specimens can thus be associated with the two female and two male *paradisea* from this area, the males differing from other subspecies in having a greatly expanded fore wing green area. The distinctness of the males supports the continued recognition of this population as a subspecies, here referred to *O. paradisea tarunggarensis* (Joycey and Talbot), **comb. nov.**

It thus appears that *paradisea* and *meridionalis* are allopatric, although they may occur in close geographical proximity. Only *paradisea* occurs in and to the north of the Weyland Mts; *meridionalis* occurs further to the west. The nearest other *paradisea* population, *O. p. flavescens* Rothschild, occurs at Etna Bay, south-west of the Weyland Mts, and thus occurs closest to the western *meridionalis* population. A further *paradisea* population occurs to the east, south of the Snow Mts (Haugum and Low, 1979). *O. p. flavescens* has females with yellow streaked femora and no pale markings in the hind wing cell, as in eastern *paradisea* populations and *p. chrysanthemum* Kobayashi and Koiwaya (1979) from Manokwari; both *p. arfakensis* and *p. tarunggarensis* females have black femora and the hind wing pale area extending well into the cell, as in *meridionalis*.

It is interesting to note that both populations of *meridionalis* occur in areas of primary rainforest on detritus sediments in the southern Depression zone. Intervening areas have been subjected to more recent inundations, which would account for the absence of *meridionalis* from these areas. The various *paradisea* populations occur to the north of this zone, with geological factors appearing less restrictive.

### Acknowledgements

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**A TRANSIENT NON-BREEDING POPULATION OF *DANAUS PLEXIPPUS* (L.) (LEPIDOPTERA: NYMPHALIDAE)  
NEAR PICTON, NEW SOUTH WALES**

By David G. James

Biological and Chemical Research Institute, PMB 10, Rydalmer, N.S.W. 2116

**Abstract**

Data on a non-breeding population of *Danaus plexippus* (L.) at a site near Picton, New South Wales, were obtained during April and May 1981. The colony was characterized by substantial immigration and emigration and is considered to have been formed by migrating individuals en route to overwintering sites in the Sydney basin.

**Introduction**

The Monarch or Wanderer butterfly *Danaus plexippus* (L.) overwinters in the Sydney area in either a breeding or non-breeding condition (Smithers 1977; James 1981). Non-breeding populations form clusters at specific sites which are used annually (Smithers 1965; James 1979). Butterflies remain at these sites for two to three months before becoming reproductively active and dispersing. Migration precedes cluster formation, although the distances travelled are probably small in comparison to the extensive migrations of the same species in North America (Urquhart 1960, 1976; James, in press). A characteristic of the autumn migration of *D. plexippus* in North America is the occurrence of large transient roosting colonies en route to the overwintering areas (Urquhart 1960). Transient non-breeding populations have also been recorded during winter in California (Tuskes and Brower 1978).

This paper presents information obtained on a transient non-breeding population of *D. plexippus* that occurred in 1981 near Picton, New South Wales.

**Methods**

The study site located 5 km west of Picton is occupied annually by non-breeding populations of *D. plexippus*. The butterflies congregate at the southern end of a north-south oriented valley at an altitude of about 250 m. Protection from southerly and westerly winds is given by the valley sides at the southern end which rise to 330 m. A group of small trees and bushes are used by the butterflies for roosting and consist mainly of *Melaleuca styphelioides* S.m. (Myrtaceae), prickly leaved tea tree, and *Lantana camara* (L.) (Verbenaceae), lantana. Larger trees (*Eucalyptus* spp.) in the area are occasionally used. The area is about 30 m long and 10 m wide.

Early morning visits between the hours of 6 and 9 a.m. E.S.T. were made to the site at fortnightly intervals from 29th March to 14th June, 1981. A sample of butterflies was taken at each visit by dislodging inactive clustering individuals into a net. Individuals were marked using the alar tag method of Urquhart (1960) and released back into the population. Tags were numbered consecutively and showed a telephone number for contact. The condition of butterflies was arbitrarily assessed as poor, good or excellent using the

degree of wing scale loss and fading as criteria (James 1981). Females were gently squeezed posterio-dorsally to determine their mating status by the presence or absence of spermatophores in the bursa copulatrix. A small number of females were dissected to provide evidence of the non-reproductive condition of the population. Estimates of the population were made by counting individuals in the clusters while they were inactive. The small area of the site and the discrete clustering behaviour of the butterflies allowed a probable high degree of accuracy in these estimates. Data on sex ratios, cluster positioning, feeding behaviour and temperatures were also obtained.

### Results

A non-breeding population of *D. plexippus* occupied the site during a four week period from 12th April to 10th May. It was not present on 29th March or 31st May. An estimated 400-700 individuals made up the population on each of three visits.

The condition of butterflies remained good to excellent throughout the period (Table 1). On 12th April many individuals had wing undersides which were faded, contrasting to the mint condition of the upper surfaces. Similar fading has been seen in individuals exposed to rain (James, unpublished

TABLE 1: Data on a non-breeding population of *D. plexippus* near Picton in 1981.

Date	Number in sample	Number tagged	Number recaptured (with %)	Sex ratio (%)		poor	Condition (%) good	Condition (%) excellent	Estimated population
				♂	♀				
29 March	—	0	—	—	—	—	—	—	0
12 April	161	155	—	94.4	5.6	2.5	87.6	9.9	600-700
26 April	128	119	2 (1.3)	87.5	12.5	0.8	61.7	37.5	400-500
10 May	241	227	10 (3.6)	82.6	17.4	1.2	85.1	13.7	500-600
31 May	—	0	0	—	—	—	—	—	0
14 June	—	0	0	—	—	—	—	—	0
<b>TOTAL</b>	<b>530</b>	<b>501</b>	<b>12 (2.4)</b>	<b>87.3</b>	<b>12.7</b>	<b>1.5</b>	<b>80.2</b>	<b>18.3</b>	<b>1500-2000</b>

data). Heavy rain occurred in New South Wales during the first week of April. Only 10% of butterflies were in an excellent condition although if "rain fading" was ignored this rose to nearly 60%. The proportion of rain faded individuals fell to 12% on 26th April when butterflies in an excellent condition made up 37.5% of captured butterflies. 5% of "excellent" butterflies had wings that were still limp and characteristic of individuals in the first few days after eclosion. On 10th May 85% of butterflies were in a good condition and 13.7% in an excellent condition. Less than 1% were rain faded on this date.

The sex ratio of the population was considerably imbalanced in favour of males (Table 1). On 12th April females made up only 5.6% of the population but this increased to 17.4% by 10th May. Nine females examined on 12th April were unmated but only eight of 16 females captured on 26th April were virgin. Similarly 22 of 42 females taken on 10th May had been mated. Seven females, taken during the clustering period and dissected, showed varying degrees of reproductive inactivity. Four had no ovarian development while three contained immature oocytes in stages of resorption.

A total of 501 butterflies were tagged and 12 (2.4%) were recaptured at the site (Table 1). Two individuals tagged on 12th April were found dead on 20th April and 2nd May, 15 and 10 km north of the site, respectively. 155 butterflies were tagged on 12th April. Two (1.3%) were recaptured at the site on 26th April and three (1.9%) on 10th May. Seven (5.9%) of 119 butterflies tagged on 26th April were recaptured on 10th May. No recaptures were made of 241 individuals tagged on 10th May.

Clustering behaviour of the population varied in an apparent response to temperature and wind strength. On 12th April the temperature at the time of visit was 12°C and the butterflies were clustered in eight major groups on the southern, western and eastern edges of the site. On 10th May four dense cluster groups occurred in a single area at the eastern edge sheltered from a strong, cold south westerly wind. The temperature at the time of visit was 5°C. Substantial feeding activity was shown by the population on each visit. Flowers of *L. camara* which occurred in profusion at the site provided the main nectar source. Profuse fat body and body weights of up to 700 mg were found in dissected females. These weights were 100-200 mg greater than average values for reproductively active *D. plexippus* and 50-100 mg greater than normal weights of females in overwintering clusters (James, unpublished data).

### Discussion

The population of reproductively inactive *D. plexippus* that occurred near Picton in 1981 was characterized by its dynamic nature and short period of site occupation. The small number of individuals recaptured at the site, together with the recovery of two away from it, suggests a high rate of immigration and emigration during the period of occupation. The discrete nature of the site, together with a relatively small and confined population of *D. plexippus* allowed comprehensive sampling and accurate visual assessments of population size. Any major change in population numbers such as that which would have occurred if immigration was not balanced by emigration, would have been detected. A similar tagging programme, conducted on a static but much less easily sampled winter breeding population of *D. plexippus*, yielded a recapture rate of 30% (James 1981). Tagging studies performed on clustering populations at other sites in the Sydney area have produced recapture rates of 20-50% (James, unpublished data). A number of other observations provide further evidence of dynamism in the Picton population. The rapid decline of easily identifiable rain faded individuals which initially accounted for half of the population suggests their emigration from the site. The increase in numbers of butterflies in an excellent condition on the second sampling date, including a number still limp from recent eclosion, indicates substantial immigration. In 1979 and 1980 smaller populations of 50-300 butterflies remained for three to four months and about 20% of individuals tagged were recaptured at the site. The 1981 population remained at the site for only four to six weeks and showed a degree of dilution and

gain not seen in the previous years. Studies at other sites in the Sydney area during 1978-81 have generally shown occupation by non-breeding populations of *D. plexippus* to last for two to three months (James 1979, and in press).

It is clear that the colony of *D. plexippus* near Picton in 1981 differed from normal reproductively inactive overwintering populations in the Sydney area. It was a transient rather than a static population and could be compared to the temporary roosting colonies of migrating populations in North America (Urquhart 1960). Individuals in the colony were probably migrants en route to overwintering sites further north in the Sydney area. Further indications that the colony consisted of migrants were provided by the dominance of males and the substantial feeding activity of the population. Clustering populations of *D. plexippus* in the Sydney area usually consist of equal numbers of males and females except during the periods of formation and dispersal, when males predominate (James 1979, and unpublished data). Although feeding activity is an essential component of behaviour in clustering populations it does not usually occur at the level seen at Picton in 1981 (James 1979, and unpublished data). Migrating *D. plexippus* in North America are characterized by high body weight and substantial feeding activity (Urquhart 1960; Brown and Chippendale 1974; Tuskes and Brower 1978).

The origin of butterflies that form clusters in the Sydney area is unclear, although it is likely that many migrate from southern and western tableland areas and follow northerly and easterly flight directions (James in press, and unpublished data). Consequently, transient colonies of *D. plexippus* are likely to occur in highland areas to the south and west of Sydney prior to reaching the lower altitude coastal basin. All large, stable non-breeding populations of *D. plexippus* in the Sydney area occur at altitudes of less than 150 m (James, unpublished data).

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A guide to the

BEETLES OF SOUTH-EASTERN AUSTRALIA

by

BARRY P. MOORE

B.Sc., Ph.D., D.Phil.

Fascicle No. 3

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*rigor mortis* will have subsided and the specimens should be in a perfect state for mounting. However, they will retain this condition for several weeks without deterioration (except perhaps, some darkening of colours), provided the container is effectively gas-tight. Thus early mounting is not essential although, when practicable, it is desirable for the best preservation of the lighter pigments.

Other killing agents, such as chloroform, petrol, or the lepidopterist's cyanide bottle cause permanent stiffness in beetles (and also more discolouration) and should be avoided, except in an emergency. Killing by freezing also leaves the specimens rather stiff but is the least harmful of all methods to delicate pigments and is to be preferred in such cases.

### *B. Preservation of natural colours*

For the most part, beetles require no more than adequate air drying to furnish entirely acceptable specimens and the rather elaborate (and messy) operation of degutting, which is so important with certain Orders [notably the Odonata (dragonflies) and larger Orthoptera (grasshoppers and crickets)], is seldom if ever necessary. Moreover, since most beetles are largely or entirely black, or exhibit metallic 'interference' colours that are based on structures of the cuticle rather than pigments, difficulties of colour preservation do not often arise. Avoidance of over-exposure to killing agent and airy conditions for quick drying after mounting will normally suffice to preserve the lighter colours of variegated species but it is probably advantageous to keep specimens of the brightly coloured Buprestidae (Jewel beetles), Scarabaeidae-Cetoniinae (Rose chafers) and other blossom feeders alive for a day or two after capture, to allow clearance of the gut contents. Species with predominantly red colouring (Coccinellidae, Endomychidae, etc.) are browned and darkened by prolonged exposure to ethyl acetate or other chemical agents and are best killed by freezing but no satisfactory way is known for preserving the fugitive colours of Leaf beetles of the large and diverse tribe Paropsini.

### *C. Storage of unmounted specimens*

As already indicated, specimens may be preserved in a relaxed state for a while in the killing bottle but after periods longer than about one month, the intersegmental membranes gradually weaken and the specimens tend to part at the joints when setting is attempted. Thus material that is not likely to be mounted for many months after capture (such as that from an extended field trip) should be packed soon after killing in unsealed tin boxes, between layers of cellulose wadding. A little trichlorocresol should be scattered at intervals through the layers to keep out moulds and pests. Cotton wool is *quite unsuitable* for packing beetles as it becomes inextricably tangled with them and is then impossible to remove without damage to dry and brittle

appendages. Unmounted specimens can be stored for long periods in a household deep freeze and if kept in closed containers, will remain suitable for immediate mounting for many months.

#### *D. Relaxing dry material*

Specimens that have been stored dry or mounted specimens that are required for dissection need to be relaxed before they can be handled further. This is best achieved by direct immersion in 2% aqueous acetic acid for 24 hours or more, according to size and age. White vinegar (but not the brewed variety), diluted with four volumes of water will also serve this purpose. Specimens are tested with the forceps at intervals and when adequately relaxed are drained on blotting paper and set in the normal way. Since beetles are entirely unharmed by this treatment (which may be repeated several times) there is no need for the more elaborate relaxing jars, crushed laurel leaves and similar devices used by collectors of Lepidoptera and other more delicate insects.

#### *E. Mounting and labelling*

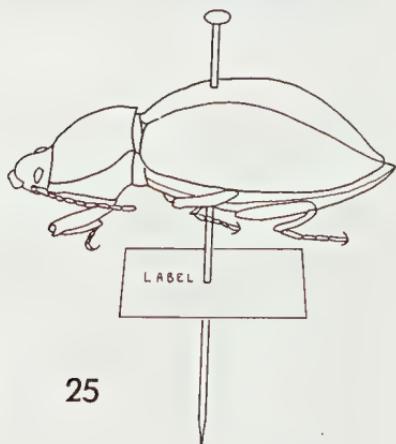
Because beetles vary enormously in size and build no one method of mounting is suitable for all species and the collector is thus at liberty to make his own selection from the alternatives available. Popular methods in common use are illustrated in Figs 25-28. The simplest is by direct pinning and this is recommended for all large, heavy-bodied species, where damage caused by penetration is quite trivial. Stainless steel insect pins should be used exclusively as the cheaper brass or ordinary steel kinds are subject to corrosion. The pin should be passed through the right elytron, at about its basal quarter, and the pin head should remain about 10 mm above the specimen to permit easy handling. The appendages of such pinned specimens should not be widely spread (except perhaps for special display purposes), for they take up too much space and are readily broken off; antennae should generally be trailed back alongside the prothorax and legs should be turned inwards, under the body and kept in place with setting pins until dry. Standard Continental insect pins (length 37 mm) that vary only in thickness are best for our purposes; ordinary domestic pins are not suitable.

Direct pinning is inappropriate for specimens much below 12 mm in length and other methods must be employed for these and for very slender specimens of greater length (e.g. many Staphylinidae). The alternatives include carding, pointing and staging (Figs 26-28). For carding (Fig. 26), a supply of Bristol board or other high quality stiff, white card is required. This is cut firstly into strips and then into rectangles, an operation best achieved by means of a photographer's guillotine. The rectangles should be of several standardised sizes that together, will suit the whole range of species to be mounted. Most collectors use a separate card for each specimen but some

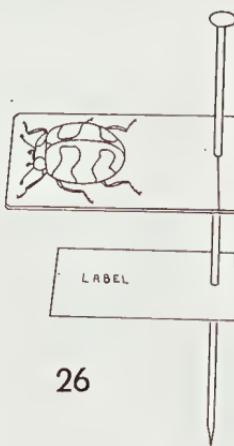
mount pairs or even series on a common card. Cards provided with a black ruled baseline (best added at the 'strip' stage of cutting) and bevelled corners have a superior appearance but take longer to prepare. They may, however, be purchased ready made from dealers.

Specimens are affixed to cards by means of a water-soluble gum that is invisible after drying. For this purpose tragacanth mucilage is by far the best and is prepared as follows: take about enough powdered gum tragacanth to cover a five-cent piece, place in a small capped tube or wide-mouthed screw-capped bottle and add ethyl alcohol to form a thin paste, followed by either a crystal of thymol or a drop of acetic acid, to serve as a preservative. Stir until uniform and then add water with continued stirring until the consistency of a thick cream is attained. Leave to stand for several hours, until any small lumps have disappeared. The paste is then ready for use.

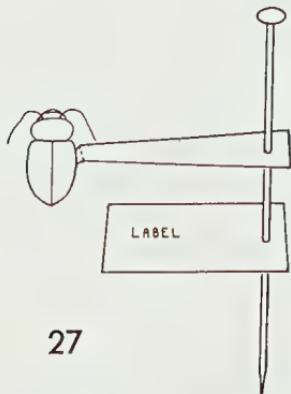
Specimens for carding should be fully relaxed; they are first laid on their backs and the appendages brushed outwards from the body. A small



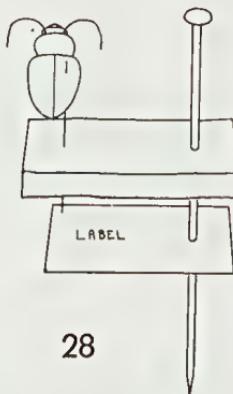
25



26



27



28

Figs 25-28. Mounting styles. (25) direct pinning; (26) carding; (27) pointing; (28) staging.  
For instructions see text.

amount of gum is placed on the card and the beetle transferred to it by means of forceps or a gum-laden brush. The appendages are then arranged symmetrically with the same brush and with just sufficient gum to hold them in place until dry. Some workers add gum arabic to their mounting medium\*, for added strength, but the resulting material is more obvious on drying. For very smooth, convex, or heavy species a drop of animal glue ('Seccotine' is one of the best) under the abdomen will give greater security. Solvent-based, plastic glues are not recommended for setting as they obscure important parts and render demounting difficult. For the sake of neatness and of ease of comparison of specimens, all cards should be carried at the same height on their pins; a pinning block made from hard wood bored to the correct depth will facilitate this (Fig. 29).

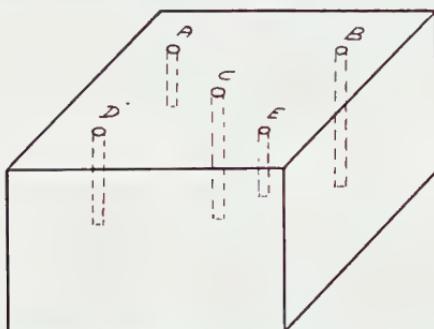


Fig. 29. Pinning block. This is a block of hard wood about 50 x 50 x 30 mm, with holes bored to appropriate depths. Hole A (depth 10 mm) is for direct pinning and takes the head of the pin, to depress the specimen to the correct level. Holes B-E take the point of the pin: B (depth 25 mm) for carding or pointing; C (depth 23 mm) for staging; D (depth 18 mm) for main data label; E (depth 13 mm) for identification label or other subsidiary data.

A disadvantage of the carding method of mounting is that the underside of the specimen is largely obscured. Therefore, whenever a series of a given species is being treated, at least one specimen should be mounted on its back. Unique carded specimens which need to be demounted for critical examination may be removed readily enough by momentary wetting with water but such treatment would prove time-consuming on a large scale, and is not without risk of damage. The main advantages of carding are neatness, attractive appearance and the degree of protection afforded to delicate specimens. Also, specimens may be drawn or photographed *in situ*, without the need for relaxing and remounting, and comparisons within series, or between species, are greatly facilitated.

In pointing (Fig. 27), which is particularly suited to quite small species, specimens are gummed on one side of the venter to the tips of small, triangular cards, carried on standard pins. Both sides are accessible to view

\* Such a medium is also available from dealers.

but parts of the underside may be obscured by the appendages or the glue. However, the main disadvantage of this method is an increased tendency for specimens to leave their mounts.

In staging (Fig. 28), specimens are spiked on stainless steel micro-pins that are then inserted into short strips of polyporus pith, which is sold by dealers for the purpose. The polyporus strips are carried on standard pins. This method is unsuited to minute species.

Whichever methods are adopted, all mounted specimens should carry a small data label on the main pin, preferably at a standard height. The data should include at least the location of collection, the date of capture and the captor's name in indelible print. Some additional information on the mode of occurrence (e.g. "at light", "on *Acacia dealbata*", etc.) will often prove valuable, although the label must obviously be restricted in size for the smaller specimens. Although hand-written labels are satisfactory if clearly printed in black drawing ink, custom printed and scaled-down labels which are now available commercially are preferable and should be used as much as possible. Some examples of data labels are shown in Fig. 30.

Iron Range, Cape York Pen. N. Qld. 20 June 1971 K. W. Walker	Mt Gingera, 1800m Brindabella Rg. A.C.T. 26 Jan. 1975 B. P. Moore	Jim Jim waterhole, N.T. 12°57'S. 132°34'E 30.I.x.1979 R. P. Weatherpoun and I. W. Hope	Gosford, N.S.W. 18.xii.1972 at M.V. lamp R. S. Brown	26 km NW of Broken Hill, N.S.W. 16 Sep. 1980 T. Humphreys	Atherton, N. Qld. bred ex pupa em. 26 Dec. 1979 H. P. Crocker
8km along Black Mt. Rd, near Kuranda, N. Qld. 16 Nov. 1972 in rainforest A. & M. Walford-Huggins	Waitara, Sydney, N.S.W. 197 at M.V. lamp M.S. & B.J. Moulds	AUSTRALIA: "Calosoma" via Gundaroo NSW. B. P. Moore	Forest litter Borlase Extract No. 283	Tachys convexus Maday comp. w. type B.P. Moore '80	Pamporus alternans Lat. det. B.P. Moore '80

Fig. 30. A selection of data labels.

More lengthy details of habitat, behaviour, etc., may be kept in a notebook or diary with, if necessary, a cross-reference number to the specimen. However, it must be emphasised that specimens with no data on their pins are of little scientific value and are likely to be discarded, once they have left the possession of the original captor.

At least one specimen of every species that has been identified should bear a second label carrying this information, together with the name of the person responsible for the determination and the year this was done. The year of determination can be important, later, in cases where changes of name or reinterpretations of existing species subsequently occur and give rise to uncertainties about earlier decisions.

#### F. Storing the collection

Fortunately, preserved beetles deteriorate very little with age and specimens adequately protected from sunlight, dust and pests may often look almost as fresh after many decades of storage as when first captured. However,

some specimens will be found to have acquired a greasy appearance and carded examples may have stained their mounts in an unsightly way. This results from gradual breakdown of body fats and the cure is total immersion of the entire mount for several hours in a suitable fat solvent. Benzene or clean petroleum spirit (e.g. lighter fluid, but not ordinary motor fuel) are ideal. After a period of airing off, the rejuvenated specimen may be returned to the collection and the remaining fluid can be reused until it assumes a distinct straw colour.

By far the worst source of trouble, under our conditions, is the ingress of pests that eat and ultimately destroy the mounted specimens. These pests include the well known Silver fish (insects of the primitive Order Thysanura), Book-lice (small, wingless Psocoptera) and beetle larvae of various families, notably the Dermestidae. The first sign of their presence is a pile of dust-like debris beneath some specimens but if unchecked, they are likely to ruin the entire contents of the container. Prevention is better than cure and the use of well made and close-fitting storeboxes or drawers, each supplied with flake naphthalene as a deterrent, together with regular inspections, should provide adequate insurance. Naphthalene is not, however, very toxic, so that once pests have gained entry through neglect, the refurbishing with this substance will not eradicate them and more drastic measures will be necessary. The best material for such eradication is carbon disulphide, a small quantity of which should be poured onto the bottom of each affected container. The latter should be closed immediately and the whole left undisturbed for a day or two, well removed from any living area, before airing off and returning to the collection. Carbon tetrachloride is nearly as effective and is more generally available (as a cleaning fluid); it has the advantage of non-inflammability and a much less unpleasant odour.

At the start, the beginner may be content with a few well made cigar boxes in which to store his specimens; such boxes should be lined at the base with a layer of sheet cork and be provided with a cell for naphthalene\*. Later, as the collection grows, he may wish to purchase the specially made store boxes available; these are generally double-sided (i.e. corked top and bottom) and they come in various sizes. Store boxes are perhaps the best compromise for the amateur with limited resources and they are well adapted to the needs of a rapidly expanding collection. Most professional workers and museums store their material in cabinets fitted with glazed, interchangeable drawers, in which each species is housed in a separate unit tray. Such a system is undoubtedly the ultimate in convenience and adaptability but is expensive in terms of both outlay and space and is probably beyond the means of most independent students.

\* Naphthalene 'moth balls' can be mounted on stout pins by heating the heads of the latter, prior to insertion. Such mounts afford a useful alternative to flake naphthalene in boxes that have no cell.

### G. Preserving beetle larvae

Although larvae of a few families, such as the Elateridae and Tenebrionidae, are sufficiently sclerotised to make good specimens on drying out, the majority shrivel badly under such treatment, unless special precautions are taken to harden them beforehand. Most collections are therefore stored permanently in alcohol. Modern storage jars (widemouth jam or pickle jars are ideal), with non-corrodible, screwcap lids and built-in, reusable seals, have largely obviated the evaporation hazards that plagued our predecessors and losses of valuable material through inadvertent drying out are now fortunately rare. All except the largest larvae are best stored in small vials which, in turn, are stowed within the jars. The vials should be filled completely with 70% alcohol and closed with a plug of wadding or cotton wool, then stacked, closure downwards, on a base of further wadding, in the jars, covered with more of the spirit and finally closed with the screwcap. Labels should be printed or written in waterproof ink and enclosed with the specimens in the vials.

Many larvae darken and/or shrivel when placed directly into alcohol, although signs of impending deterioration may not appear for several days; all specimens should therefore be fixed before storage in this medium. The darkening is due to the presence of the enzyme tyrosinase, which needs to be inactivated by heat, by treatment with phenylthiourea, or by contact with a fixative containing acetic acid. Specimens may therefore be killed by dropping into boiling water or by 'pickling' in KAA fixative\* for several hours; they are then drained on blotting paper before permanent transfer to 70% alcohol (ethanol or methylated spirit), to which a little phenylthiourea may have been added. Fixatives containing formalin (such as Pampel's fluid†) leave specimens stiff and difficult to manipulate, dissect or macerate and are best avoided, except where the intention is to prepare dry mounts.

Larvae that have shrivelled through inadvertent drying may be restored by immersion in *cold* and *very dilute* caustic potash (potassium hydroxide) (0.1%) for a few days, followed by a similar period in 2% formalin. They may then be returned to alcohol for permanent storage. Exuviae may be cleaned or whole specimens cleared for critical study, by simmering in 5% caustic potash, followed by passages through clean water and then alcohol. Such specimens are best preserved in the form of microscope slides, with 'Euparal' as the embedding medium.

Some of the larger, fleshy beetle larvae make reasonably lifelike cabinet specimens if emptied and inflated. In this technique, the anus is enlarged and the body contents squeezed out by gentle rolling with a glass rod. The empty skin is then attached to a syringe, inflated to natural proportions, and allowed to dry in that state, preferably with the aid of a little artificial heat. Unfortunately, certain species discolour badly under these conditions.

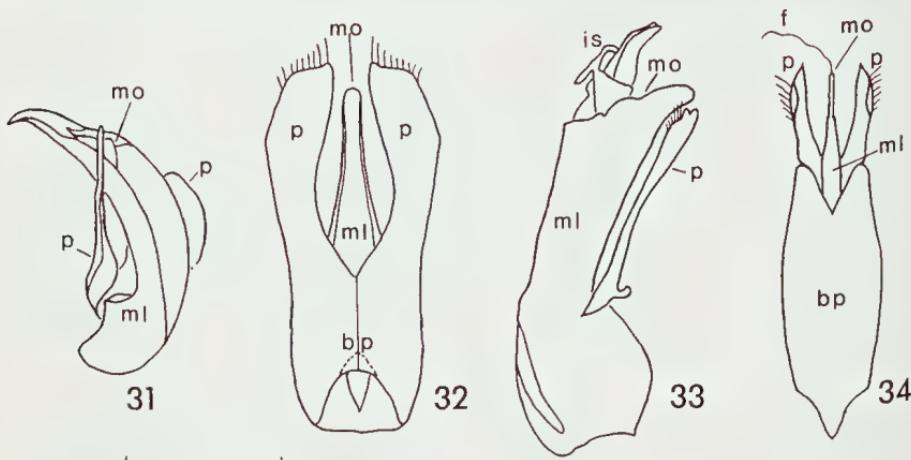
\* 95% ethyl alcohol (77), glacial acetic acid (15), kerosene (8).

† 95% ethyl alcohol (27), water (55), glacial acetic acid (7), formalin (11).

Satisfactory dry mounts may also result from specimens that have been well fixed in Pampel's fluid. After fixation for several weeks, such specimens should be thoroughly dehydrated in alcohol (several changes) and then cleared in xylol or chloroform, before being allowed to dry off. If adequately prepared such mounts may prove perfectly satisfactory for display purposes although they are hardly suitable for critical study. Patience is the key to success with this technique, for any attempt to shorten the hardening or clearing stages will inevitably lead to inferior results.

### H. Dissecting

The general student will not be greatly concerned with adult internal organs but the sclerotised parts of the male (and sometimes, also the female) genitalia are important aids to identification in many families and should be extracted as a matter of course from one or two specimens in each series. This is best done with freshly killed material, at the time of mounting, when



Figs 31-34. Sclerotised parts of male genitalia (aedeagi). (31) *Rhytidosternus miser* Chd. (Carabidae), right lateral; (32) *Aulonogyrus strigosus* F. (Gyrinidae), ventral; (33) *Creophilus erythrocephalus* F. (Staphylinidae), left lateral; (34) *Lamprima aurata* Latr. (Lucanidae), dorsal.

bp, basal piece; f, flagellum; is, internal sac; ml, median lobe (penis); mo, median orifice; p, paramere. Scale line = 0.5 mm for (32), 1 mm for the others.

the parts are readily removed by merely inserting a fine steel entomological pin into the anal aperture. A pin, the point of which has been bent round to form a small hook, will prove particularly useful for the purpose. For some special studies the genitalia will need to be preserved in liquid or made into a permanent slide mount but, for ordinary purposes, they should be gummed to the card carrying the specimen or to a subsidiary card beneath it. Some examples of male genitalia (aedeagi) and their parts are illustrated in Figs 31-34.

Dissection of the mouthparts will also be required in certain groups. Here again, freshly killed beetles are the easiest to work with, but relaxed specimens are also quite suitable. No attempt should be made to dissect specimens in the dry condition. For cutting purposes, a fine scalpel will serve well but a good alternative may be obtained by breaking a sharp razor blade at an angle of about thirty degrees. A glass dish filled with plasticine or paraffin wax will provide a suitable substrate for dissection work.

## IDENTIFICATION

### General

Australian coleopterists are at a considerable disadvantage in comparison, say, with their European counterparts, because the local beetle fauna is not well known or adequately documented. There are none of the manuals or distribution charts that form so much a part of the northern hemisphere entomological scene, yet we have to deal with a very large number of species that are widely dispersed over a big country. We ourselves are relatively few and thinly spread—and the overall dryness and unpredictability of our climate render collecting on an adequate scale a demanding and rather chancy business. Then it must be conceded that the Australian beetle fauna poses special taxonomic problems on account of the frequent occurrence of large clusters of closely related species.

The local situation is not without its advantages of course: there is undoubtedly more scope for original observation here, but the full exploitation of such advantages is impeded by difficulties of identification or of access to information that may already have been published. Doubtless, many budding young coleopterists in this country will have been put off by such difficulties and the frustration they engender, but by recognising local limitations from the outset—and learning to live with them—it is possible to make the best of the situation and still find plenty to do that is both useful scientifically, and of absorbing interest. The following notes are therefore offered with this need in mind.

Because beetles are so numerous in species and so diverse in form, the identification of specimens from even the most restricted locality or habitat is seldom a simple matter. Experience counts for a great deal, for although a well illustrated handbook and access to a good named collection are invaluable aids to such a task, they are in no way an effective substitute for a sound working knowledge of the Coleoptera and familiarity with the particular fauna at hand. Thus the well practised coleopterist will generally have little difficulty in placing a beetle into its correct family, even though the species may be entirely new to him. His trained eye has come to recognise the general characteristics of each beetle family and only the most atypical specimen will require lengthy checking through the keys and published descriptions to this level. A lot of time and effort is thereby saved, for comprehensive family keys are, at best, complicated and difficult to use (even for the specialist) because they need to be all inclusive and must cater for many aberrant species as well as the more typical forms. Keys to genera or to species, on the other hand, cover smaller and smaller numbers of organisms and are thus more simple and straightforward. In dealing with species, the expert is also at an advantage over the tyro, for not only will he be aware of the points to look for, but he will generally know which groups can be reliably identified at sight, or by quick matching with named series, and which cannot, without a great deal of close study or research.

The beginner, then, would be best advised to start by making a small collection of the larger beetles of his district, including as many different families as possible. The collection should be kept general, with no attempt at specialisation for the first few seasons at least, and its owner should not be unduly concerned about the number of unidentified or partly identified specimens it contains. He should, however, attempt to classify all of his captures into families, firstly with the aid of practical information and illustrations in the present book, and later by comparison of general structure and form with those that he has already identified. When sufficient broad experience has been gained in this way, some form of specialisation should be contemplated, for our beetle fauna is so large that no one can hope to cover all of it. The new enthusiast may therefore concentrate on one or two families that specially appeal to him, or that happen to be well represented in his particular area; or he may limit his interest to the species of a single locality or of a well defined but restricted habitat (e.g. beetles of the seashore, or those associated with a particular tree or plant; water-beetles of a garden pool; fungus beetles; beetles of stored products; cave beetles, and so on). Some students may prefer to concentrate on elucidating life-histories; others will be attracted by the problems of classification or of geographical distribution.

By the time an appropriate collection has been built up, its owner should be over the first major hurdle and in a position to identify many of the more common and distinctive species that come his way. He may then try his hand at using published keys to the various levels that concern him and ultimately, attempt to identify some of his 'unknowns' by reference to larger named collections, or to appropriate papers in the research literature. He should also make every effort to exchange ideas with others of similar interests and to seek expert guidance at the nearest State museum.

## The Literature

An excellent introduction to the Australian Coleoptera, including 'systematic' keys to families, a bibliography and many fine illustrations, is provided by Dr E. B. Britton's chapter in the textbook "The Insects of Australia" (Melbourne University Press, 1970 and Supplement, 1974) and some further information may be gleaned from similar chapters in the works of Tillyard (1923) and McKeown (1942). A most useful illustrated work by E. G. Matthews, covering the genera of South Australia, is currently being published in parts. For the rest, accounts of our native beetles are largely restricted to the research literature and access to this is best achieved through use of bibliographies and catalogues of various kinds. Musgrave's (1932) "Bibliography of Australian Entomology 1775-1930" covers the earlier literature but entries are listed under authors and only limited cross indexing to subjects is provided. A continuing bibliography by M. S. Moulds, in *Australian Entomological Magazine*, deals in a similar way with publications

since 1972. However, in order to uncover information concerning individual species, the student most often needs to consult compendia dealing with the entire world fauna. The *Coleopterorum Catalogus* is the usual starting point for this type of inquiry and access to a copy is essential for any serious study. Fortunately, the work is available in most entomologically orientated institutions and also from some of the larger public libraries. It is a large, multi-volume work published by Junk (pronounced 'Yoonk') of the Netherlands (and formerly of Germany), during the first half of the present century and revised editions of some of the earlier fascicles continue to appear from time to time. Often referred to simply as the 'Junk Catalogue', this indispensable compendium endeavours to list every known beetle species and the principal literature references to it. References to more recent literature and to descriptions of new species published after the appearance of the relevant volume of the Junk Catalogue may be obtained by consulting, year by year, the *Insecta* sections of the annually published *Zoological Record*. Unfortunately, the latter very important work is currently lagging some six years behind the primary literature it aims to cover and there is no very satisfactory way of fully bridging the gap. However, *Biological Abstracts*, *Entomological Abstracts* and their annual indexes provide an interim cover that is more up-to-date, though less complete.

One of the prime requirements of any would-be specialist is an up-to-date check list of the species (and their synonyms) in his chosen group, but the only comprehensive list of Australian beetles, that of Masters (1885-87) is now so old as to be of little more than historic interest. In general, then, and unless his chosen group has been reviewed recently, the student must prepare his own list, starting with the latest available and making such changes and additions as may be indicated in the systematic portion of the *Insecta* section of the *Zoological Record* or in any other pertinent papers that he comes across. In cases where there is no workable local list, the starting point must be the Junk Catalogue and it will be necessary to leaf through the relevant volume(s), page by page, in order to extract all included Australian records. Although this can prove a rather tedious exercise, it will always repay the keen student with an improved perspective of his group, to say nothing of the satisfaction accruing with completion of the task. Once drawn up, the check list will remain an invaluable tool for as long as the interest persists and if set in the form of a card index, it will be readily kept up-to-date.

The advanced worker should also maintain an adequate card index of recent salient references to his field and, if he ultimately intends to describe new taxa, he will need to be familiar with the latest edition of the "International Rules of Zoological Nomenclature" (International Zoological Commission, London, 1964). He will also need to consult Neaye's *Nomenclator zoologicus* (1939-75). The latter important work lists all generic names proposed in zoology from Linnaeus, 1758, to 1965 and recourse to its seven

volumes, together with subsequent annual lists in the *Zoological Record*, is essential to ensure that any proposed new name is not preoccupied. Mayr's "Principles of Systematic Zoology" (1969) is a mine of helpful information and suggestions for those undertaking taxonomic revisions and the publication of their findings.

## LIST OF FAMILIES

The following table indicates the currently accepted systematic positions of the beetle families known from, or likely to occur in, the south-eastern States. Families to be considered in subsequent keys are indicated in bold type. The figures in brackets represent the approximate tallies (large totals rounded upwards) of known Australian species.

### ORDER COLEOPTERA

#### SUBORDER ARCHOSTEMATA

##### SUPERFAMILY CUPEDOIDEA

**Cupedidae** (6)

#### SUBORDER MYXOPHAGA

##### SUPERFAMILY SPHAERIOIDEA

**Sphaeriidae** (2)

#### SUBORDER ADEPHAGA

##### SUPERFAMILY CARABOIDEA

<b>Rhysodidae</b> (12)	<b>Noteridae</b> (4)
<b>Carabidae</b> (1700)	<b>Dytiscidae</b> (180)
<b>Haliplidae</b> (5)	<b>Gyrinidae</b> (30)
<b>Hygrotiidae</b> (3)	

#### SUBORDER POLYPHAGA

##### SUPERFAMILY HYDROPHILOIDEA

<b>Hydrochidae</b> (10)	<b>Georyssidae</b> (3)
<b>Spercheidae</b> (1)	<b>Histeridae</b> (150)
<b>Hydrophilidae</b> (90)	

##### SUPERFAMILY STAPHYLINOIDEA

<b>Hydraenidae</b> (6)	<b>Silphidae</b> (3)
<b>Limulodidae</b> (6)	<b>Scaphidiidae</b> (20)
<b>Leiodidae</b> (30)*	<b>Staphylinidae</b> (700)
<b>Scydmaenidae</b> (80)	<b>Pselaphidae</b> (500)

\* = Anisotomidae

## SUPERFAMILY SCARABAEOIDEA

Passalidae (35)	Trogidae (41)
Lucanidae (80)	Scarabaeidae (2500)

## SUPERFAMILY EUCINETOIDEA

Scirtidae (60)*	Clambidae (11)
Eucinetidae (?)	

## SUPERFAMILY DASCILLOIDEA

Dascillidae (2)	Rhipiceridae (9)
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## SUPERFAMILY BYRRHOIDEA

Byrrhidae (50)	
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## SUPERFAMILY DRYOPOIDEA

Callirhipidae (4)	Limnichidae (10)
Ptilodactylidae (5)	Helminthidae (90)
Heteroceridae (10)	Psephenidae (1)

## SUPERFAMILY BUPRESTOIDEA

Buprestidae (800)	
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## SUPERFAMILY ELATEROIDEA

Elateridae (800)	Throscidae (4)
Eucnemidae (80)	

## SUPERFAMILY CANTHAROIDEA

Lampyridae (16)	Lycidae (210)
Cantharidae (100)	

## SUPERFAMILY DERMESTOIDEA

Derodontidae (?)	Dermestidae (60)
Nosodendridae (1)	Jacobsoniidae (?)

## SUPERFAMILY BOSTRYCHOIDEA

Anobiidae (100)	Bostrichidae (40)
Ptinidae (62)	Lyctidae (5)

## SUPERFAMILY CLEROIDEA

Trogositidae (30)	Phycosecidae (3)
Cleridae (300)	Melyridae (250)

## SUPERFAMILY LYMEXYLOIDEA

Lymexylidae (10)	
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## SUPERFAMILY CUCUJOIDEA

Protocucujidae (1)	Mycetophagidae (6)
Sphindidae (5)	Ciidae (13)
Nitidulidae (120)	Melandryidae (12)
Rhizophagidae (8)	Mordellidae (125)
Boganiidae (3)	Rhipiphoridae (57)
Phloeostichidae (3)	Archeocrypticidae (5)
Passandridae (6)	Colydiidae (100)
Cucujidae (50)	Merycidae (2)
Silvanidae (45)	Zopheridae (1)
Cavognathidae (1)	Chalcodryidae (1)
Cryptophagidae (5)	Tenebrionidae (1300)
Biphyllidae (21)	Lagriidae (30)
Propalticidae (1)	Alleculidae (200)
Lamingtoniidae (1)	Meloidae (60)
Languriidae (11)	Oedemeridae (90)
Erotylidae (81)	Prostomidae (6)
Phalacridae (72)	Mycteridae (10)
Cerylonidae (14)	Pythidae (13)
Discolomidae (11)	Salpingidae (20)
Corylophidae (26)	Inopeplidae (3)
Coccinellidae (260)	Anthicidae (180)
Endomychidae (32)	Euglenidae (74)*
Merophysiidae (1)	Scaptiidae (16)
Lathridiidae (34)	

## SUPERFAMILY CHRYSOMELOIDEA

Cerambycidae (1100)	Chrysomelidae (2100)
Bruchidae (14)	

## SUPERFAMILY CURCULIONOIDEA

Nemonychidae (1)	Attelabidae (70)
Anthribidae (60)	Apionidae (31)
Belidae (160)	Curculionidae (4000)
Brenthidae (33)	

\* = Aderidae



LARVAE OF THE TETRAHEDRONEURIDAE	
Trichopteridae (1)	<i>Trichopteridae</i> (1)
Acaridae (5)	<i>Ceratophyllidae</i>
Mallophoridae (2)	<i>Mallophoridae</i> (2)
Rhipiphoridae (1)	<i>Rhipiphoridae</i> (1)
Thysanidae (1)	<i>Thysanidae</i> (1)
Colpocephalidae (1)	<i>Colpocephalidae</i> (1)
Dermaphilidae (9)	<i>Dermaphilidae</i> (9)
Chenopidae (2)	<i>Chenopidae</i> (2)
Lavidae (3)	<i>Lavidae</i> (3)
Coccoquadridae (1)	<i>Coccoquadridae</i> (1)
Cryptophoridae (2)	<i>Cryptophoridae</i> (2)
Dipteridae (1)	<i>Dipteridae</i> (1)
Proctotrupidae (1)	<i>Proctotrupidae</i> (1)
Leptophidae (1)	<i>Leptophidae</i> (1)
Thaumaleidae (1)	<i>Thaumaleidae</i> (1)
Hemipteridae (3)	<i>Hemipteridae</i> (3)
Phaenidae (1)	<i>Phaenidae</i> (1)
Staphylinidae (2)	<i>Staphylinidae</i> (2)
Diaspididae (1)	<i>Diaspididae</i> (1)
Coccoidea (1)	<i>Coccoidea</i> (1)
Homoptera (1)	<i>Homoptera</i> (1)

LARVAE OF THE TETRAHEDRONEURIDAE (CONT'D.)	
Homoptera (1)	<i>Coccoidea</i> (1)
Homoptera (1)	

LARVAE OF THE TETRAHEDRONEURIDAE (CONT'D.)	
Homoptera (1)	<i>Homoptera</i> (1)
Homoptera (1)	









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